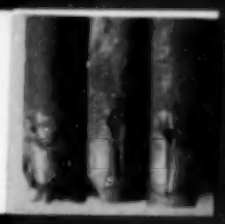
Chemical Engineering Progress

case history:
Evaporator Corrosion



JUNE 1956

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in Chemical Plant Construction

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makes the difference!

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Central Romana By-products Co., Inc.
in Dominican Republic

DOMINICAN REPUBLIC

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Build a plant for producing profitable chemicals from wastes at sugar-mill site in West Indies.

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Recently at a sugar-mill site in the Dominican Republic *Vulcan Construction Division* assisted in the construction of a processing plant for the production of valuable chemicals from waste bagasse. Vulcan Construction experts on the job made every minute and every man count. With a small U.S. crew, Dominican workers were trained to high-skill levels in welding, brazing, forming, fitting, handling and placing heavy process equipment. Distillation towers, condensers, exchangers, pumps and process and service piping were assembled and installed at the plant site. Ox-carts were used to haul materials within the construction area! In spite of obstacles, Vulcan completed the job on time at a below-estimate cost.

Let us bid on your next job and learn for yourself the important value of sound experience combined with practical ingenuity in the field—all backed by an organization with 55 years in designing and building chemical plants and equipment. It's a combination which can make the difference between confusion and costly delay—and on-time, on-budget completion.

VULCAN CONSTRUCTION DIVISION OFFERS:

- *Overall plant construction services including site preparation, foundations, structural steel, buildings, equipment erection, machinery setting, piping, instrumentation, electrical work, insulation and painting.*
- *Renovation of existing plants both large and small.*
- *Field erection and installation of equipment.*

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Chemical Engineering Progress

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prevent overloading of production units

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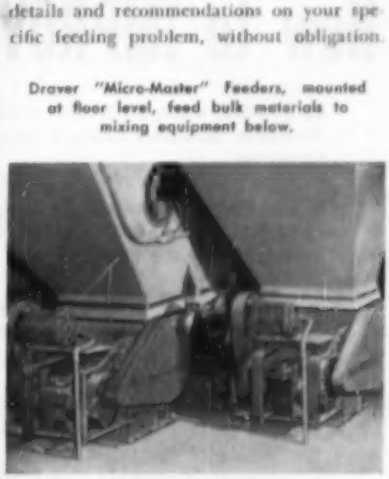

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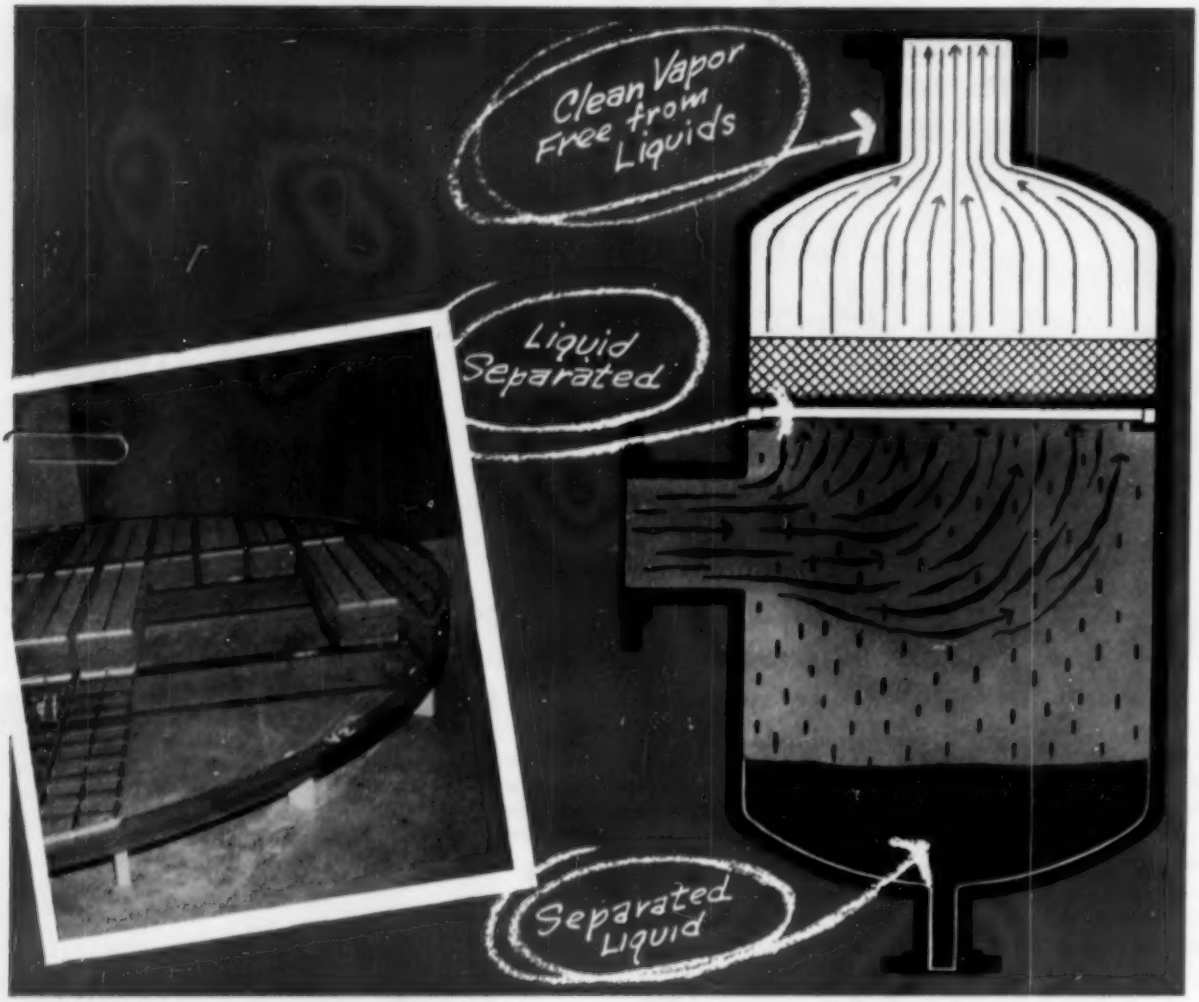

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In **distillation equipment** liquid entrainment is controlled, giving better quality overhead products even at increased thruput rates.

In refinery **vacuum towers,** higher quality gas oil means higher conversion rates to gasoline in the cat cracker.

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Noted and quoted

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During the past ten years, investments in plants and equipment for chemicals and allied products exceeded $10 billion. The industry has grown five times in size over the past 25 years but major segments of it could double in the next ten. It is growing three times faster than industry generally, spends far above the average on research, employs more scientists and engineers. . . .

The big question . . . is who will do the research, the engineering, the commercial development of this expanding industry in the years ahead? Who will be the leaders? . . . Don't tell me that is the job of the public relations people or the job of the trade associations, or somebody else. It is our job, the job of everyone who has a stake in building this industry . . . Certainly if industry growth is a function of research . . . then our national strength . . . will be dependent . . . upon our technological strength and vigor . . .

In our great concern with things and dollars, with facts, figures, estimates and potentials, in our preoccupation with plans, we sometimes forget the essential ingredient, people. In our devotion to molecules we may forget men. . . .

We know we cannot continue to build our chemical industry by technology alone, nor alone by commercial development, nor solely by investing in new, better and bigger plants. We need all of these, but the essential ingredient is the individual, the scientist, the engineer, the teacher, the leader. The essential ingredient in our building for the future is the builder. Our well-laid plans will stagnate if these talented, trained, dedicated people . . . are not available. . . .

John R. Hoover
Speech before Commercial Chemical Development Association, Inc.

Robots Cannot Think!

These machines [robot machines] give every appearance of doing some powerful thinking and in our process of self-deception we forget that all of the real thinking had been done beforehand by the designer or engineer. . . .

Whether it's an electronic oracle or a television shusher, it's just another tool that man has devised to save himself work, and it is his servant, not his master. . . . It cannot decide to do anything on its own initiative. . . .

Julius Guhl
Minneapolis-Honeywell Regulator Company

(*Continued on page* 12)

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CHEMICAL ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

Chemically inert TEFLON® simplifies design in new mechanical seal

...offers economical service on pumps handling corrosives

TEFLON® can now be cemented with conventional adhesives

A new process provides a cementable surface on shapes fabricated from "Teflon" tetrafluoroethylene resin. Chemically inert, "Teflon" normally refuses to stick to anything. After treatment, however, "Teflon" may be bonded with conventional adhesives to a wide range of other materials as well as to itself.

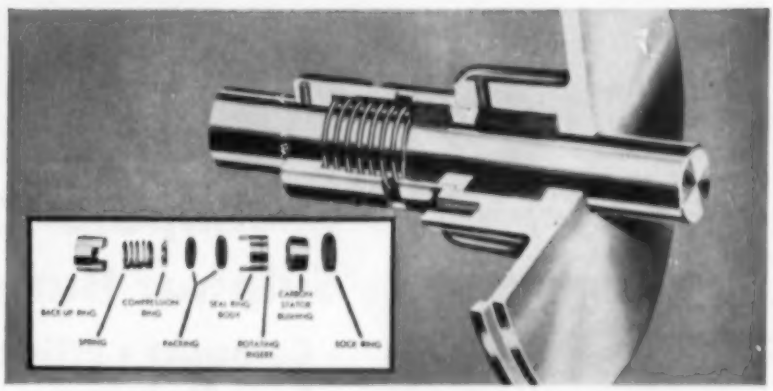
Fittings of ZYTEL® provide leak-proof connections on tubing

Compression-type "Jaco" fittings of molded "Zytel" nylon resin simplify installation and disassembly. In this new design, the ferrule necessary for a leak-proof seal is molded as an integral part of the nut. The resiliency of "Zytel" enabled this fitting to withstand a test of more than 25,000,000 oscillations. "Zytel" forms a non-corrosive connection, impervious to most acids and alkalies, and capable of withstanding pressures to 500 p.s.i. Its service temperature ranges from –70° to 295° F. Fittings are molded by Jaco Manufacturing Company, Cleveland, Ohio.

This versatile Du Pont engineering material is a time and cost saver in many applications where lightness in weight, heat resistance, corrosion resistance and strength in thin sections are essential. Investigate this product further by mailing the coupon below.

NEED MORE INFORMATION?

Clip the coupon for additional data on the properties and applications of these Du Pont engineering materials.



Exploded and cross-sectional view of new mechanical seal, with parts of "Teflon" shown in red. Seal can be rapidly interchanged with packing.

Latest design in mechanical seals features complete and rapid interchangeability with packing. Developed by Chemical Power and Products, Inc., New York City, this new seal can be made to fit any stuffing box, requiring no alterations or special clamps. It offers economy by eliminating product loss and minimizing installation and downtime.

"Teflon" tetrafluoroethylene resin plays the feature role in the sealing of corrosive liquids and slurries. It is used as a shaft packing in the form of a male and female cup, and providing maximum flexibility with minimum spring pressure as a wedge lock in the bottom of the seal to prevent leakage and stop rotation of the stator. The self-aligning wedge lock of "Teflon" slips easily in place, and the time and expense involved in installing a clamp to hold the stator are eliminated.

"Teflon" is selected in sealing applications because of its superior physical and chemical properties. "Teflon" is chemically inert—alkali metals and fluorine, under unusual conditions, are the only ordinary industrial chemicals which will attack it. This unique engineering material will operate at service temperatures ranging from –450° to 500° F. "Teflon" is non-flammable, and has zero water absorption by ASTM test. It has low-temperature toughness and an exceedingly low coefficient of friction.

For handling corrosive chemicals, "Teflon" offers unexcelled service for such items as pump impellers, expansion-joint bellows, filters, tubings, and gaskets and packings. If you have a problem involving extreme heat and corrosion, investigate the use of "Teflon." For property data that will help you analyze your problems in terms of this unique material, clip and mail the coupon below.

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Room 796 Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada Limited, P.O. Box 660, Montreal, Quebec

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I am interested in evaluating these materials for

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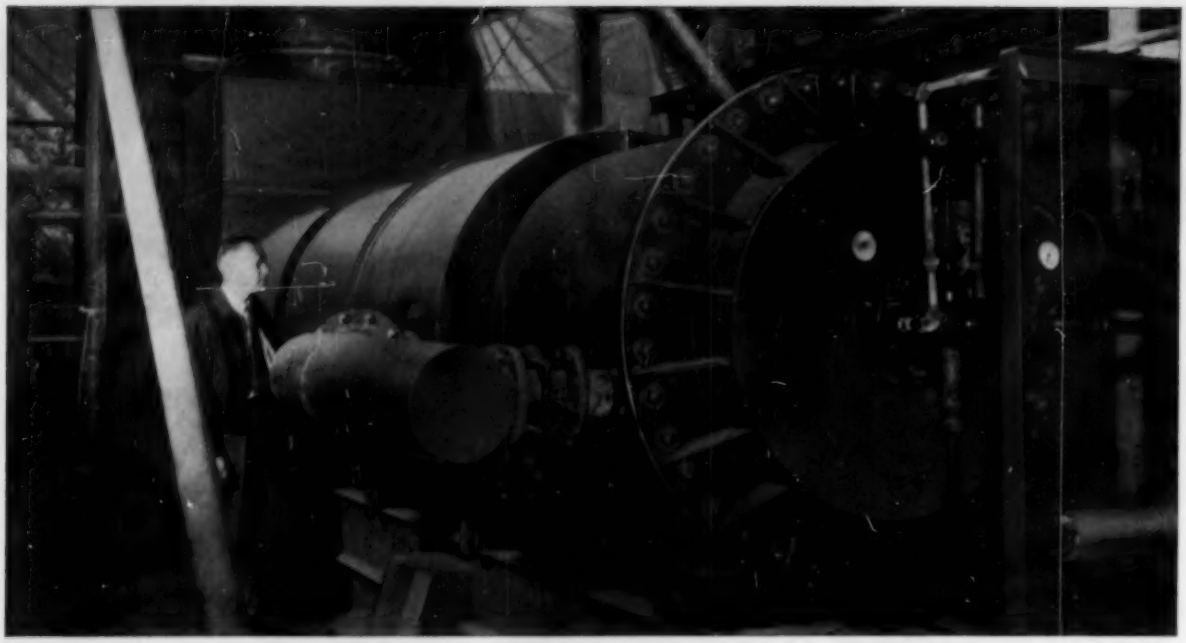

This 15-ton-per-day Chemipulp-KC sulphur burner operates at 18.5% SO_2

The secondary air admitted through the manifold shown, is preheated in the space between the outside of the burner and the surrounding jacket. This preheated air assists in combustion and in maintaining a high percentage of SO_2

Chemipulp-KC Jet Type Sulphur Burner

- **Compact • Efficient • Long Life**
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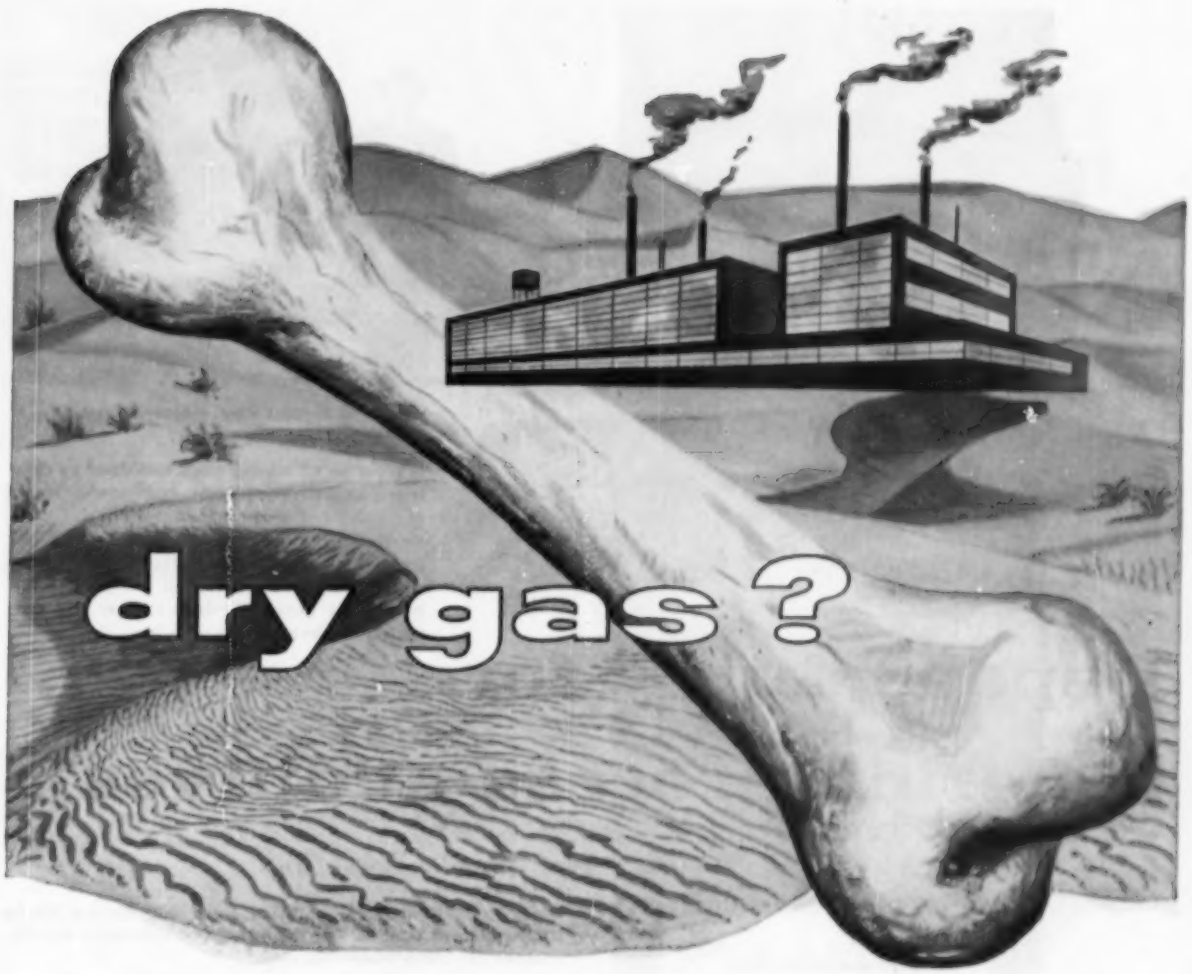

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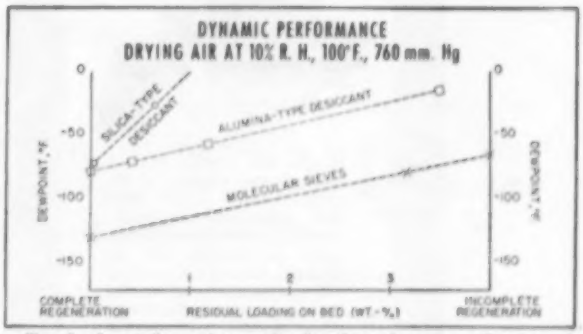
This is SUPER-drying! Dynamic performance is shown in the accompanying graph. This superior performance also can be expected at higher relative humidities and at other temperatures and pressures. Of particular significance in production is the relative insensitivity of Molecular Sieves to incomplete regeneration.



For further information, write for data sheets on "Drying of Gases." Address Dept. **CP-6,** Linde Air Products Company, A Division of Union Carbide and Carbon Corporation, 30 East 42nd St., New York 17, N. Y.

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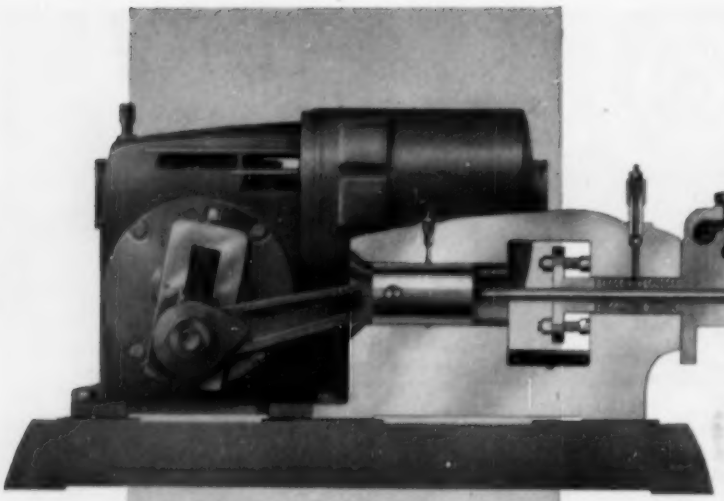

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• Wear on all moving parts minimized by close tolerance machining of cross-head, pump frames and liquid end parts. • Excessive packing wear avoided by large length-to-diameter ratio of cross-head which fully supports plunger. • Long service life under shock and oscillating loads assured by generously-sized reducer and connecting rod bearings.

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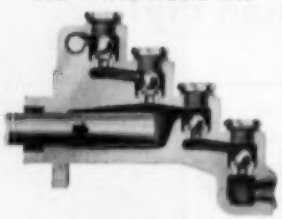

Double ball checks, sloping passages and absence of air pockets assure highest possible volumetric efficiency. Should a solid particle lodge under one suction ball, for example, second suction ball will seat on discharge stroke, thereby preventing fluid from being pumped into suction piping.

MILTON ROY dependability means long service life in your controlled volume pump . . . minimum maintenance . . . lower operating cost.

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New **ACE RIVICLOR®**

Corrosion-resistant plastic piping

RIVICLOR, newest of all rigid plastic pipe, heads the list for resistance to chemicals and excellent aging characteristics . . . plus high strength, toughness and easy workability.

Riviclor is unplasticized polyvinyl chloride, specially formulated for process piping. Non-toxic, non-flammable, excellent insulating properties. Only half weight of aluminum. Never needs painting. Smooth inner surfaces give you high flow rates with low loss of head.

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Use Riviclor for all in-plant piping of mild or strong corrosives at normal temperatures . . . for liquid lines where "sweating" or corrosive vapors are problems . . . for underground piping. Pipe, fittings, diaphragm valves from ½" to 2".

Ask for Technical Bulletin CE-56.

ABBREVIATED TABLE OF CHEMICAL RESISTANCE

ACIDS		BASES		MISCELLANEOUS			
Acetic 50%	S	Ammonium Hydroxide 28%	S	Ethyl Alcohol	S	Carbon Tetrachloride	S
Chromic 25%	S	Sodium Hydroxide 50%	S	Methyl Ethyl Ketone	U	Plating Solutions	S
Hydrochloric 38%	S	HALOGENS		Gasoline	S	Photographic Solutions	S
Hydrofluoric 50%	L	Sodium Chloride Sat.	S	Mineral Oil	S	KEY: S—Satisfactory	
Nitric 20%	S	Ferric Chloride	S	Animal Oil	S	L—Limited to certain applications	
Sulphuric 50%	S	Sodium Hypo-chlorite 5%	S	Vegetable Oil	S	U—Unsuitable	
Sulphuric 98%	S			Phenol 10%	S		
				Chlorine 5%	L		
				Alum	S		

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY

93 WORTH STREET • NEW YORK 13, N. Y.

Noted and quoted

(*Continued from page 6*)

Atoms for Asia

Atomic energy will offer immense possibilities for improving living standards in under-developed countries when atomic power stations can be built economically enough to produce cheap power. Though this may take ten or fifteen years to achieve . . . next month [March] a committee of the U. N. Economic Commission for Asia and the Far East is meeting in Bangalore, India, to discuss the part atomic energy will eventually play in Asian countries.

The committee will examine ways in which industrially advanced nations . . . can help . . . These include assistance in training technicians, international exchange of information on latest nuclear techniques, and prospecting of natural resources for radioactive minerals.

(*UNESCO*)

Fusion and Fission

If one calculates the energy available from fusion of the light nuclei, one finds that, pound for pound of raw material, fusion is more energy-productive than fission. But one cannot, for this or any other reason, say, "a fusion reactor *is* better because . . ." None has been built yet, nor is one likely to be in the near future. It has taken a decade of applied research—of a very high order of excellence—to bring nuclear power reactors (based on fission) even to the present state of the art, where none is yet operating in this country on an economical basis. Controlled fusion, like the impossible, "will take a little longer."

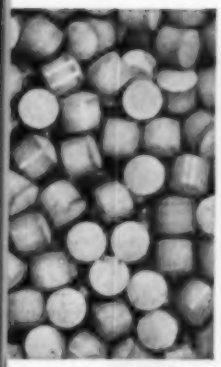
Industrial Bulletin
Arthur D. Little, Inc.

Great Expectations in the South

The opportunities for economic growth and development in the southern states during the next 20 years are greater than those in any other section of the country. Today we live in an economy of abundance, not an economy of need. The provision of the bare necessities of life, such as food, shelter, and clothing, has become an accomplished fact for substantially all of our people. . . . And our dynamic, technological economy makes it possible to look into the future with confidence that the standard of living of the country will continue to increase.

. . . To many Southerners, the pot of gold at the end of the rainbow looks

(*Continued on page 18*)

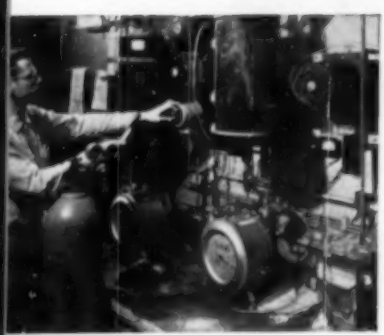


Plus values of Girdler Catalysts

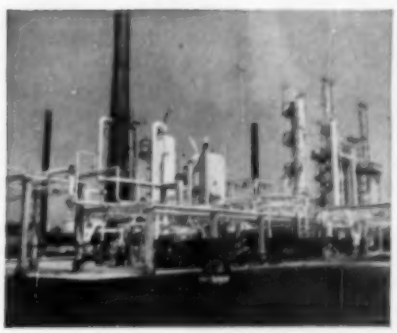
APPLICATION SERVICE
DEVELOPMENT SERVICE
ANALYTICAL SERVICE
MARKET SERVICE
ADVANCED PRODUCTION

A full-scope catalyst service to improve your processing

KEYSTONE of Girdler's co-ordinated catalyst testing work is its development service. Here, highly-skilled technicians work with modern laboratory equipment (like this pilot type autoclave) to create new catalysts and improve existing ones. Girdler's full-scope catalyst service is helping many processors in a wide range of applications boost production and lower costs. Find out how it can work for you to your advantage.



MARKET RESEARCH specialists investigate customer's specific problems and create catalysts to meet their specific needs. They also help develop new end products and improve quality, made possible through better catalysts.



FIELD SERVICE fully complements Girdler's broad catalyst research activities. Girdler's trained specialists work closely with customers at their plants—make sure they get the best possible results from Girdler Catalysts.

FINEST QUALITY and peak performance of Girdler catalysts is assured by our Analytical Service. This vital branch not only monitors our production, but also does valuable "trouble-shooting" analytical work when Girdler customers encounter problems.

CATALYST DEPARTMENT

The GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION: New York, San Francisco **VOTATOR DIVISION:** New York • Atlanta • Chicago • San Francisco

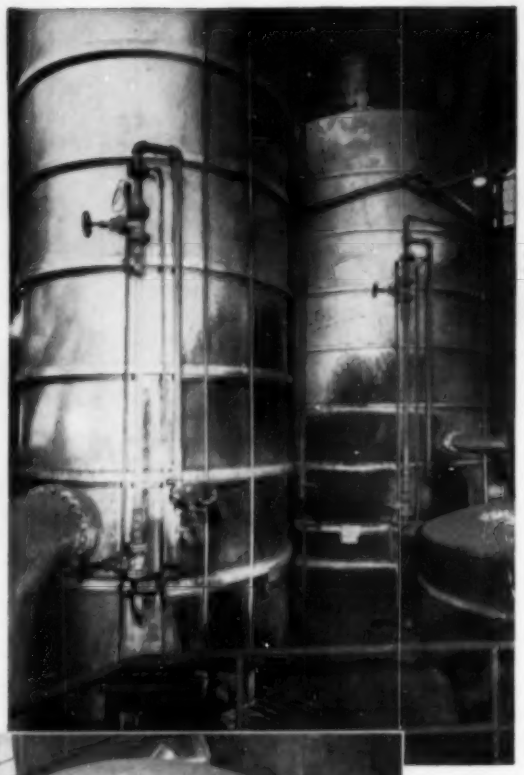
In Canada: Girdler Corporation of Canada Limited, Toronto

A TRIO FOR PROCESSING PROBLEMS

CONKEY CRYSTALLIZERS, EVAPORATORS AND FILTERS

This is the *trio* that will remedy your crystallizing, evaporating or filtering problems. All three are built to the rugged Conkey design, fabricated in Chicago Bridge & Iron Company's four strategically located shops.

If your plant has a filtering, evaporating or crystallizing problem, write our nearest office. A Conkey engineer will be happy to assist with information, estimates or quotations.



Top: Conkey all nickel construction Triple Effect Evaporator producing 50 per cent caustic liquor.

Above: Conkey Triple Effect Vacuum Crystallizer producing ammonium sulphate.

Left: Conkey Rotary Hopper Dewaterer in service dewatering abrasive grains.

CHICAGO BRIDGE & IRON COMPANY

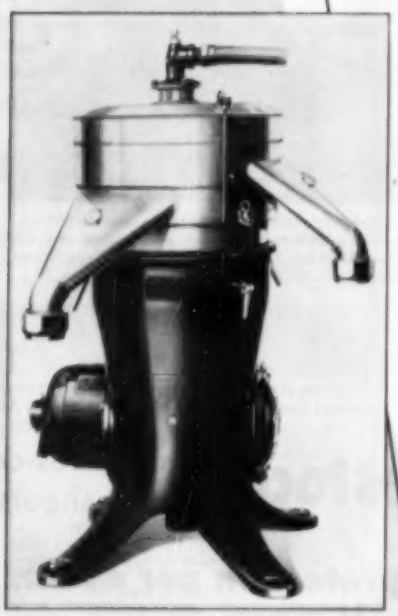
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

CONKEY EQUIPMENT

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa

STRAIGHT LINE

...shortest distance to profits!



Why separate with slow, roundabout filters or settling tanks—when you can use a time-saving, profit-making *straight-line* method? . . . De Laval Centrifugals!

Many of the most efficient chemical and food plants find that De Laval Centrifugals make separation a *continuous* process, eliminate production bottle-necks, cut costs.

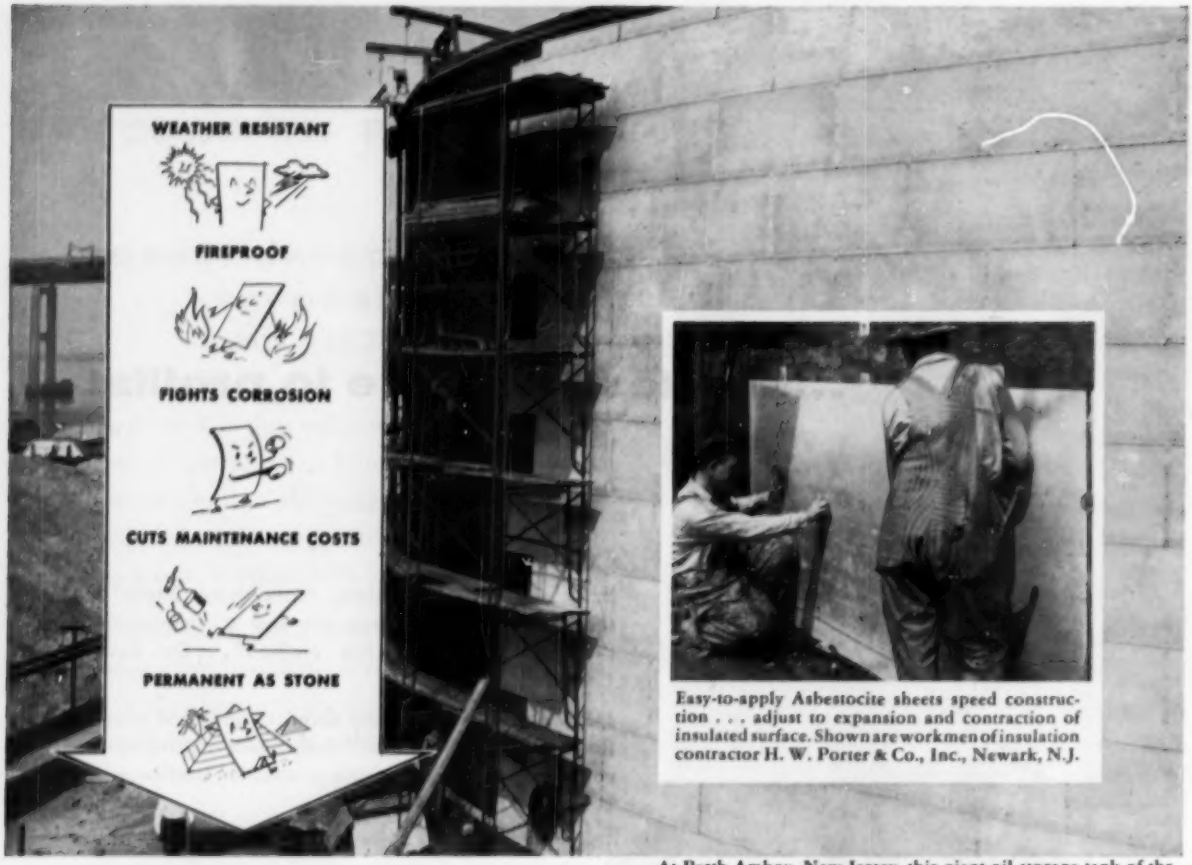
They have discovered that De Laval Centrifugals —whether used for separation, clarification or concentration—quickly pay for themselves . . . frequently *improve the product* by doing a *better* job.

Get the facts on what De Laval Separators and Clarifiers can do for you . . . now!

DE LAVAL

for faster processing systems

THE DE LAVAL SEPARATOR COMPANY Poughkeepsie, New York • 427 Randolph St., Chicago 6 • DE LAVAL PACIFIC CO. 201 E. Millbrae Ave., Millbrae, Calif.



Easy-to-apply Asbestocite sheets speed construction . . . adjust to expansion and contraction of insulated surface. Shown are workmen of insulation contractor H. W. Porter & Co., Inc., Newark, N.J.

At Perth Amboy, New Jersey, this giant oil storage tank of the Reserve Terminal Corporation is protected with J-M Asbestocite.

5 reasons why J-M Asbestocite® asbestos-cement sheets

give insulated equipment more protection per dollar

NO OUTDOOR INSULATION JOB is really complete unless it is provided with permanent protection against weather. That's why so many engineers specify Johns-Manville Asbestocite® for protecting insulated tanks, vessels, towers, stacks and other outdoor equipment.

Asbestocite combines these five important advantages in one material:

Weather resistant—Asbestocite is unaffected by exposure to sun, wind, rain, snow or temperature extremes.

Fireproof—Made of cement and asbestos, inorganic Asbestocite will not burn . . . approved by Underwriters' Laboratories as incombustible.

Fights corrosion—Nonmetallic, Asbestocite is immune to most corrosive elements found in industrial atmospheres.

Cuts maintenance costs—Under normal conditions, Asbestocite maintains its neat, attractive appearance with little or no maintenance. Needs no preservative treatment.

Permanent as stone—Stonelike Asbestocite is practically indestructible. It has virtually unlimited service life.

J-M Asbestocite is made of asbestos and cement combined under tremendous pressure into a uniform, monolithic sheet. Its stone-grey color provides a handsome appearance. Write for free brochures IN-121A and IN-173A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.

For small diameter equipment, J-M Asbestocite is available *precurved* for easier application and snugger fit as shown above on vessel at Standard Oil Company of California's Richmond refinery.

Johns-Manville *first in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

DURCOPUMPS

DURCOPUMP INSTALLED IN 1928

...and still full of *Vinegar!*

The DURCOPUMP shown above in vinegar service, was installed in 1928 in what is now The National Fruit Product Company's Eastern Division plant. It has been in steady service ever since; surviving a fire in 1932 which all but destroyed the plant. It has not been repacked in the last five years!

DURCO products are designed for long life and trouble-free service. For the answers to your corrosives handling problems, call or write

Series H DURCOPUMP

DURCO

THE DURIRON COMPANY, Inc.
Dayton, Ohio

BRANCH OFFICES: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dayton, Detroit, Houston, Knoxville, Los Angeles, New York, Philadelphia, Pittsburgh.

"Piping costs run typically as high as 50 to 70 per cent of the cost of equipment to which the piping is connected, and as high as 15 to 20 PER CENT OF TOTAL PLANT COST!"

(Chemical Engineering, Dec., 1955)

If not adequately compensated for, vibration, expansion, and shock due to sudden changes in temperature and pressure is RIGHT NOW shortening the life of your piping.

Packless® seamless flexible metal hose is designed, engineered and manufactured to absorb this costly beating your piping system is now taking — and do it efficiently and economically.

Let us show you how Packless® flexible metal hose installed in your piping system can save you *hours* in down time and *dollars* in money.

Available from stock in Bronze, Carbon Steel and Monel, with standard or special fittings as required.

Custom engineering service for your specific requirements is available at any time at no extra cost.

PACKLESS

METAL HOSE, INC., 31-51 Winthrop Ave., New Rochelle, N. Y.

Noted and quoted

(Continued from page 12)

remarkably like a test tube since the South is betting on chemicals in a big way to help its growth. Some 710 million dollars for new chemical plants were spent in the South in 1954 and another 780 million dollars are on the way.

This industrial surge is largely the product of research and includes such technical operations as the production of petrochemicals, synthetic fibers, and light metals which owe their existence to the laboratory. In this challenging climate, the South is beginning to build its own research and development facilities to insure its future growth and this, rather than the vast expansion of manufacturing facilities, is the real industrial revolution in the South.

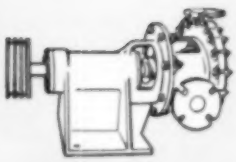
Frank J. Soday
Address before 1956 Southern Conference of Controllers Institute of America

Chemical Industry in Canada

The chemical manufacturer in Canada faces a difficult situation because of limited home markets. For example, the Canadian consumption of a given product may be, say, six or eight million pounds per year. To produce such a product economically, the total market might represent the lowest minimum on which reasonable competitive costs can be achieved. To be competitive with foreign producers and imports, the Canadian manufacturer, therefore, must of necessity obtain the whole market or find if he can only supply a share of the market he is eliminated by excessive production costs due to being forced to operate at a reducted rate of production. The market for any product must be sufficiently large to warrant installation of an economical unit of production before manufacture of new products can be undertaken and Canadian manufacturers generally plan their original new plants with a leeway of at least 50% over existing market requirements. In some recent developments in Canada . . . capacity installed has been greatly in excess of expected domestic requirements, so in some lines Canada has a great surplus of productive capacity with very limited export possibilities in these particular products.

Victor G. Bartram
before 5th semiannual meeting and winter conference, Manufacturing Chemists' Association, Inc.

(Continued on page 30)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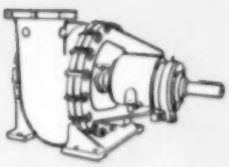
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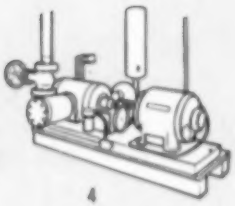
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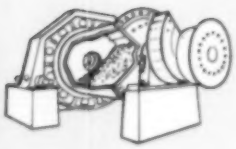
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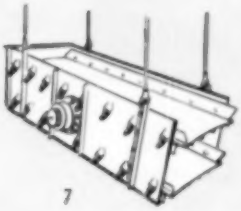
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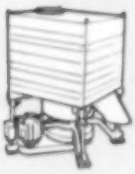
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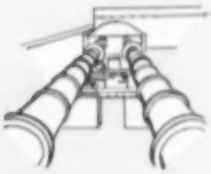
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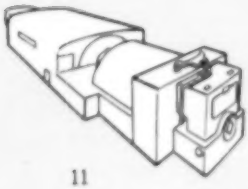
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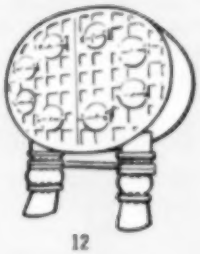
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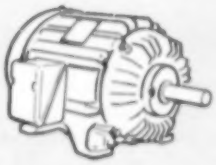
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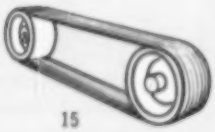
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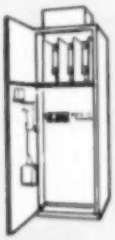
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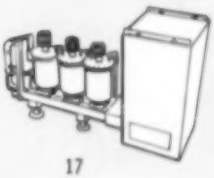
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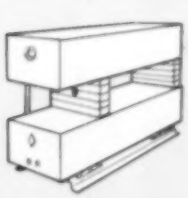
. . . What single manufacturer builds all this equipment for the **CHEMICAL PROCESSING INDUSTRIES?**

A-5111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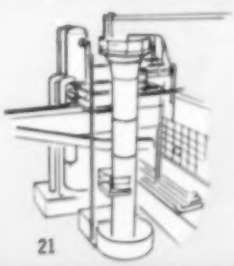
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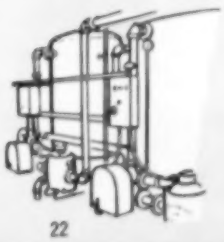
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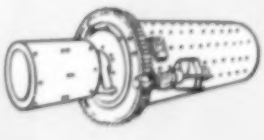
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Improve Product Quality, Streamline Production,

in hundreds of different

GYRATORY CRUSHERS

"One-man, one-minute" product control, a feature of Allis-Chalmers primary, secondary and tertiary gyratory crushers, slashes setting changing time from hours to seconds. Size adjustment, compensation for wear and emergency unloading are accomplished by the flick of a switch.

Other A-C crushers include complete size ranges in five types of jaw crushers, a line of roll crushers and an impact hammermill.

GRINDING MILLS

Whether your process calls for individual mills or a grouped stage grinding series, Allis-Chalmers can make a right-for-the-job recommendation from *seven different types* of grinding mills.

VIBRATING SCREENS

Allis-Chalmers vibrating screens are built in single and multiple-deck models for use in scalping, wet or dry sizing, washing, rinsing, dewatering, and media recovery. Auxiliaries or modifications include step decks, pool washing decks, heat expanding decks, decks designed to prevent blinding, special dust enclosures, water-cooled mechanisms, automatic stop control.

BLADE MILLS

Designed for large tonnages of hard-to-wash materials, blade mills effectively disintegrate and wash into suspension tenacious clays and other unwanted substances.

CENTRIFUGAL PUMPS

More than 60 years' experience in designing centrifugal pumps goes to work for you when you specify Allis-Chalmers. The line includes process and solids handling pumps as well as general purpose types.

ROTARY KILNS

All welded, one-plate-to-a-circle construction, patented heat recuperation, effective air seals, centralized control, air-cooled feed and discharge ends — these are some of the many improvements engineered by Allis-Chalmers that make the rotary kiln the most efficient method of pyro-processing.

ROTARY DRYER-COOLER

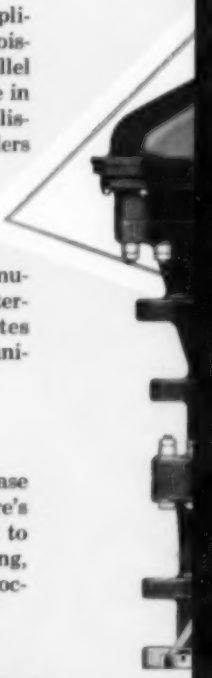
This versatile equipment is particularly applicable in drying or cooling heavy or high moisture content materials. It dries with a parallel flow and cools with a counterflow. Available in direct, indirect, or direct-indirect types. Allis-Chalmers also builds tube-type rotary coolers and air-quenching grate coolers.

GYRATORY SCREENS

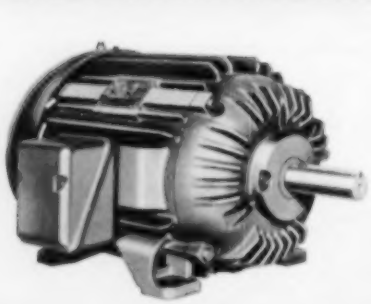
All-metal unit is designed to separate dry granular materials into two, three and four predetermined sizes. Stacked sieve design facilitates quick product change-over and simplified sanitation.

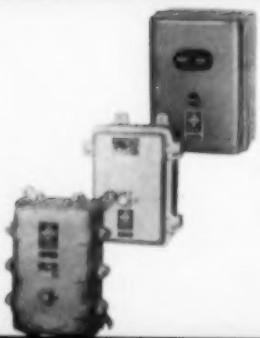
COMPACTING MILLS

Used to produce paper-thin flakes or to increase the apparent density of your product. There's an Allis-Chalmers mill specifically designed to handle a wide variety of grinding, crushing, rolling or compacting jobs in the chemical processing industries.



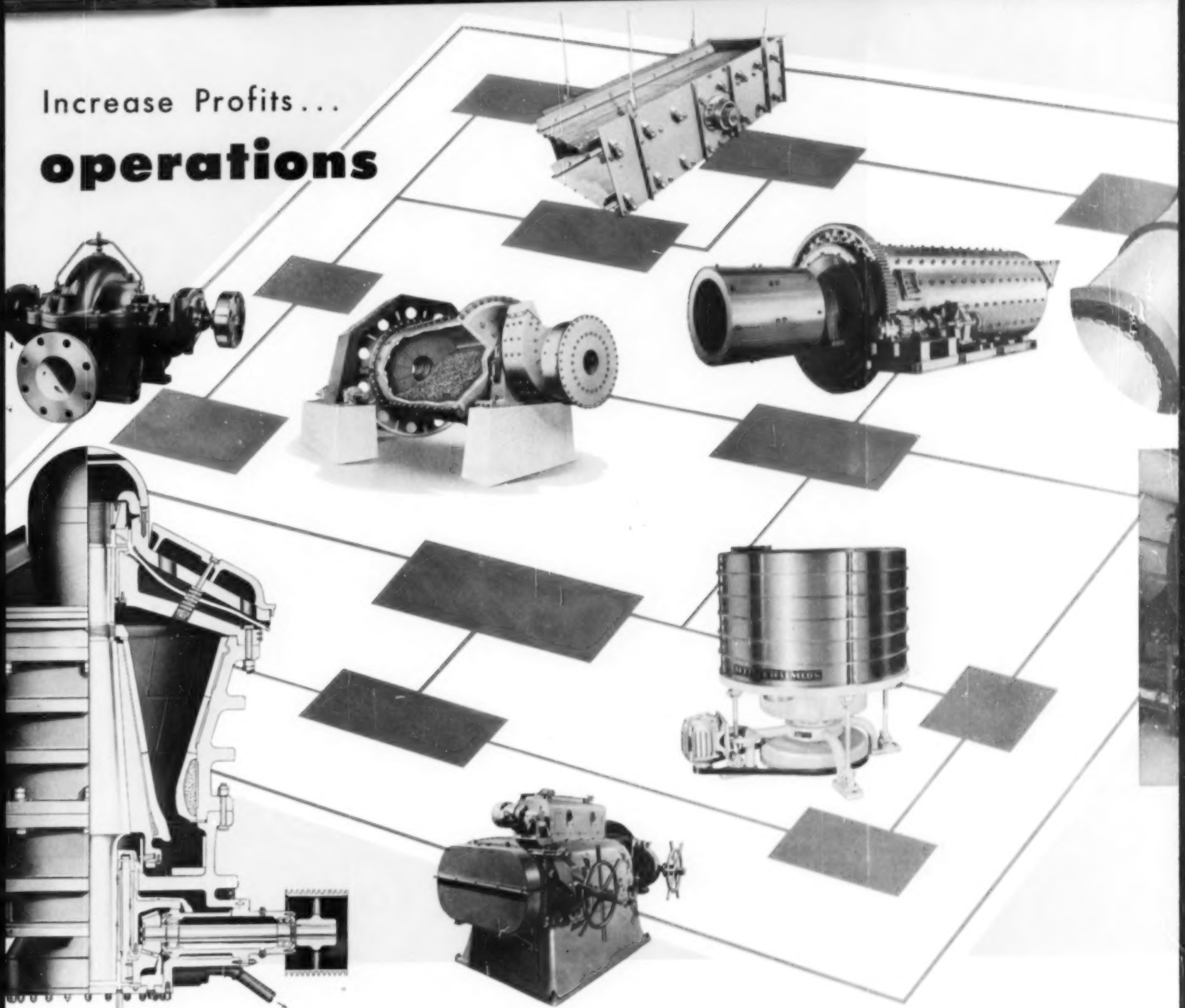
. . . all completely integrated with the required electrical equipment.





Increase Profits . . .

operations

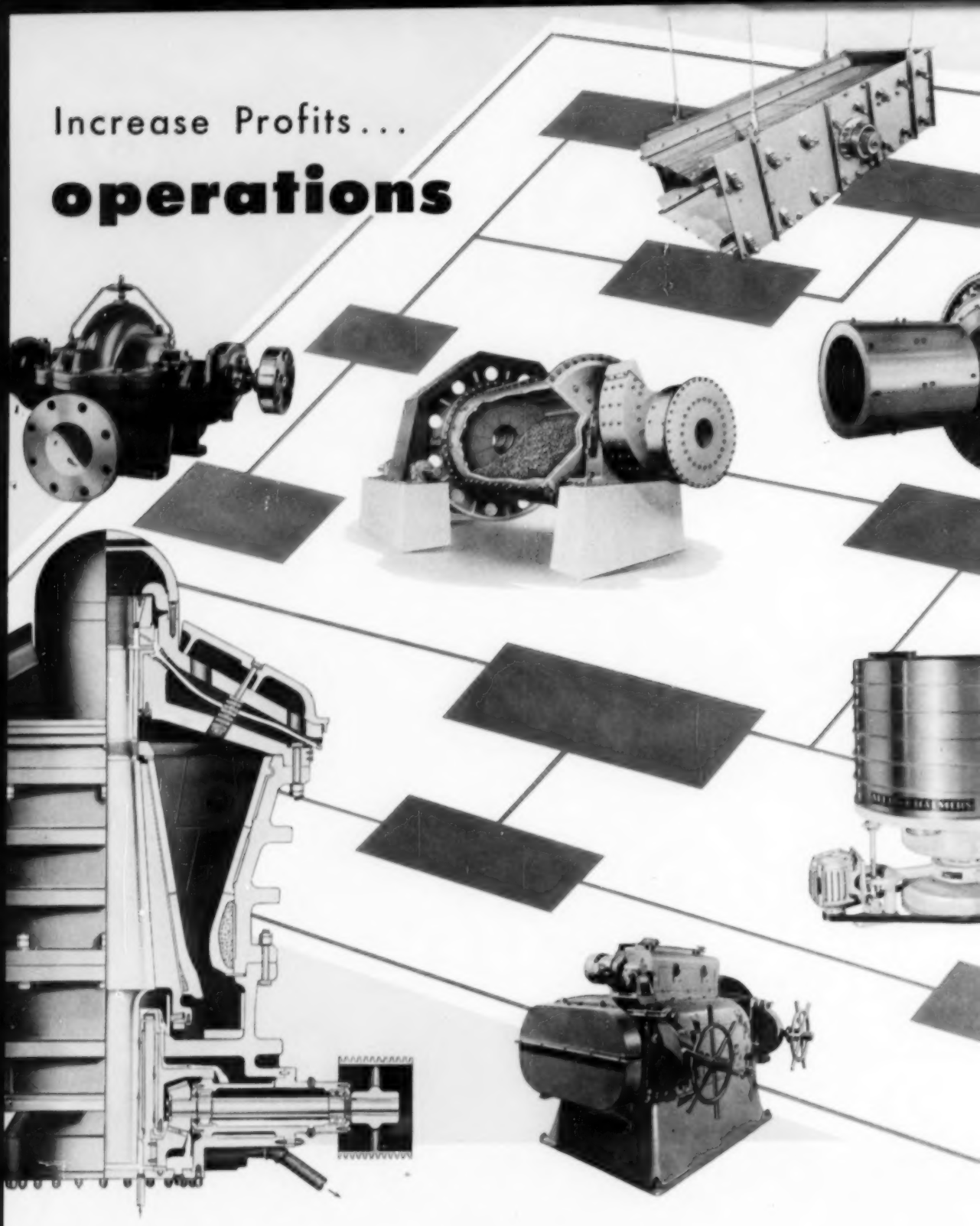


ALLIS-CHALMERS

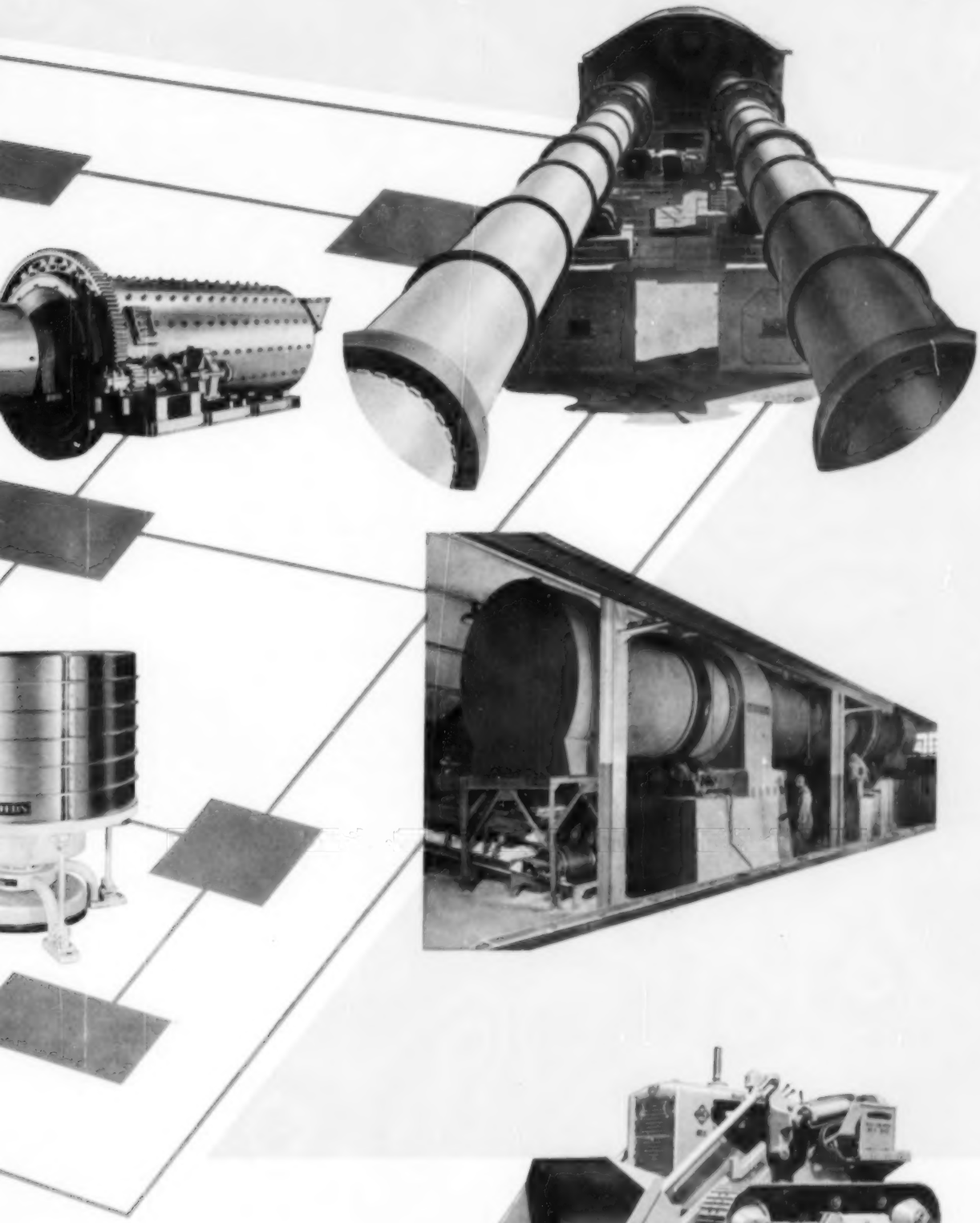
A-C ALLIS-CHALMERS

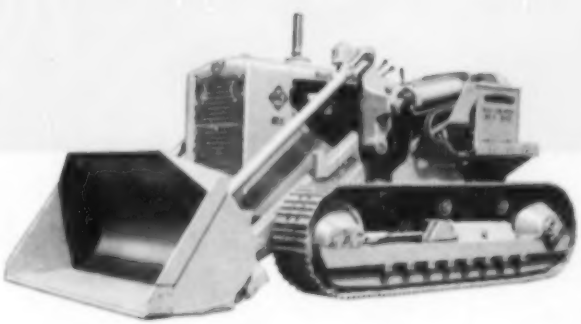
Increase Profits . . .

operations



ALLIS-CHALMER



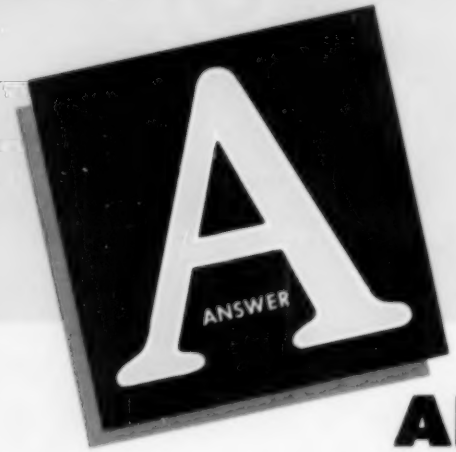


RS

A-C
ALLIS-CHALMERS

Equipment for Materials Handling

Thousands of world famous Allis-Chalmers tractors, tractor shovels, lift trucks, bulldozers and scrapers are working indoors and out in the chemical processing industries.



ALLIS-CHALMERS

. . . manufactures the most complete and diversified lines of equipment for unit operations

Allis-Chalmers builds equipment for liquid handling, air and gas handling, size reduction, wet and dry screening, washing, pyro-processing, materials handling. Equipment recommendations are based on the coordinated thinking and planning of various engineering groups at Allis-Chalmers. This unique service "teams up" new equipment with existing equipment in your operation. Electrical equipment, too, is integrated into each process. Responsibility for efficient operation rests with just one manufacturer — a big advantage.

There's No Guesswork

In working with your staff or consultants, your A-C representative uses the technical skill and experience of the many Allis-Chalmers engineering departments. Their recommendations are backed by research, by testing and pilot plant facilities, by the "know-how" gained in solving thousands of equipment application and coordination problems.

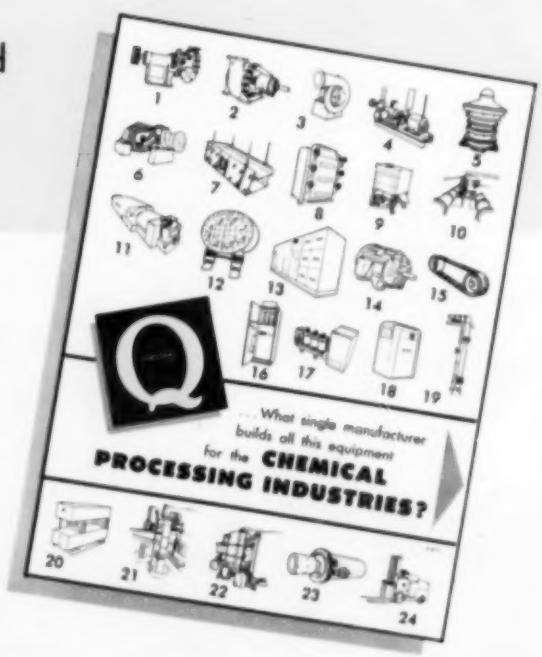
Unbiased Recommendations

Because Allis-Chalmers builds many types and sizes in a given line, equipment selection is dictated only by your specific needs.

Most important is the fact that Allis-Chalmers interest in your problem does not stop when your equipment is installed. Periodic check-ups, maintenance and technical advice, fast emergency parts service, are yours continuously.

How many pieces of Allis-Chalmers equipment did you identify in the cover illustration?

1. Process Pump; **2.** Solids Handling Pump; **3.** Centrifugal Blower; **4.** Rotary Compressor; **5.** Gyratory Crusher; **6.** Grinding Mill; **7.** Vibrating Screen; **8.** Roller Mill; **9.** Gyratory Screen; **10.** Rotary Kiln; **11.** Turbine Generator; **12.** Condenser; **13.** Unit Substation; **14.** Explosion-Proof Motor; **15.** V-belt Drive; **16.** Motor Control; **17.** Mercury Arc Rectifier; **18.** Dielectric Heater; **19.** Manlift; **20.** Metal Detector; **21.** Continuous Contact Column (for liquid-solids separation); **22.** Water Conditioning Equipment; **23.** Blade Washer; **24.** Lift Truck.



You get **MORE** than equipment when you specify

ALLIS-CHALMERS

The "plus" you get is the Allis-Chalmers approach to equipment application. It's called "*coordineering.*" As manufacturers of a most diversified line of processing and electrical equipment Allis-Chalmers maintains separate departments, each staffed with specialists, for each product. "Coordineering" is an advantage that results from an interdepartment exchange of ideas and the correlation of specific skills . . . the integration of thinking, planning and engineering that precedes the application of your integrated equipment.

Write for Literature

A 32-page bulletin (25C6177) covers all Allis-Chalmers equipment for the process industries. This bulletin, as well as literature covering specific equipment lines, may be obtained from the Allis-Chalmers representative in your area or by writing Allis-Chalmers, Industries Group, Milwaukee 1, Wisconsin.

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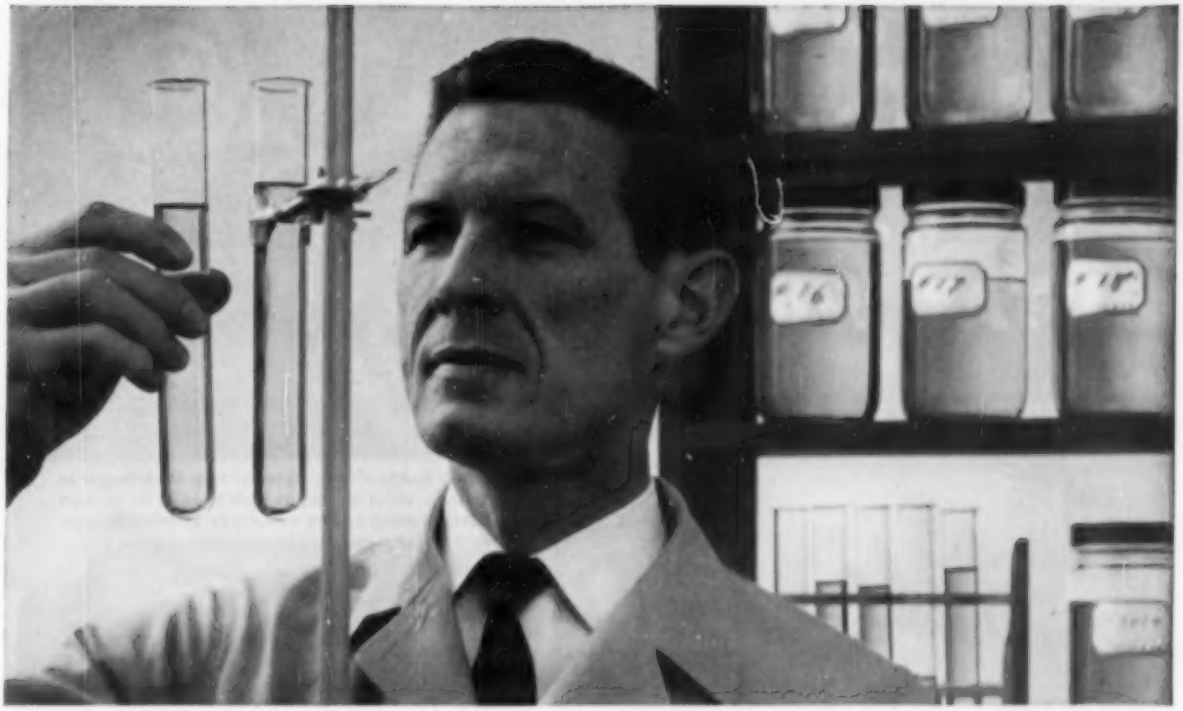
ALLIS-CHALMERS

A-C ALLIS-CHALMERS

DOW



DOWTHERM assures true color in batch after batch, uniform heat transfer and fraction-of-a-degree accuracy.

Dowtherm eliminates off colors and spoiled batches

Operating in a closed vapor system and at extremely low pressure, Dowtherm simplifies process operation . . . permits the use of more compact, thinner-walled equipment.

Up goes resin and drying-oil quality . . . thanks to precise, uniform process heating with Dowtherm

Like other industries that require high, accurately controlled temperatures in processing products—resin and drying-oil processors are taking the long-range view of profits, costs, and product quality . . . and are installing Dowtherm® heated equipment. Small wonder! For this modern heat transfer medium overcomes the disadvantages of both direct fire and liquid phase heating; provides temperatures to 750°F. at pressures below 160 lbs. p.s.i.

But most important—this pressure-controlled heat assures completely uniform heating, *accurate within a fraction of a degree.* Eliminated are fluctuations and local overheating of a product in process! No longer do off colors and spoiled batches reduce quality, eat up profits!

Shouldn't *your* plans include a look at Dowtherm? It operates on a closed vapor system, but contains no minerals to cause scale difficulties. In fact, processors report 50% savings in maintenance! And if your process cycle requires alternate heating *and cooling*, Dowtherm serves as a liquid coolant in the same equipment. For all the facts write THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. DO825B.

you can depend on DOW CHEMICALS DOW

MAKING "Rain Drops" the BUTAY WAY...

Outside Redler elevates material from track hopper to discharge either at storage tank or to 30 ft. inclined conveyor which in turn delivers to a horizontal conveyor on the plant roof.

This 5-inch Redler conveyor on roof receives material from the 30 ft. inclined Redler and in turn carries it 51 ft. to the point of discharge into plant (right foreground).

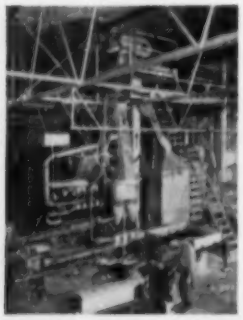
WITH AN S-A ENGINEERED BULK MATERIAL HANDLING SYSTEM!

Manufactured by the Butay Products Company, Los Angeles, "RAIN DROPS" is a water softening and blueing agent. To provide swift, economical conveying and mixing of this product's base ingredient, Stephens-Adamson engineered a system which saves many costly material handling hours.

Completely automated, this system consists of a batch skip, mixer unit, and L-type sealed casing Redler conveyors which eliminate all dusting problems. From the point of delivery outside the plant to the packaged product itself, raw material moves swiftly and smoothly by 100% mechanical means.

The Butay installation is an outstanding example of Stephens-Adamson overall planning. More than 50 years' experience in designing and manufacturing equipment that conveys at lowest cost per ton qualifies S-A for any assignment in mass movement of bulk material.

Close-up view of Redler elevator showing double leg at head end, assuring perfect discharge. Discharge is to storage or to roof conveyor. Rate 10 tons per hour. Sealed casing of Redler permits outside operation without housing.



Complexity of layout is illustrated by this interior processing station photo. Skip delivers to mixer which dumps to hopper feeding L type Redler. Mix is then delivered to packaging machine or to storage.

There is an S-A sales engineer in your area. Contact him for sound advice in your conveying problems.

STEPHENS-ADAMSON MFG. CO.
57 Ridgeway Ave., Aurora, Ill.
Los Angeles, Calif.—Belleville, Ontario

ENGINEERING DIVISION
Designers and manufacturers of all types of bulk materials conveying systems.

STANDARD PRODUCTS DIVISION
A complete line of conveyor accessories—centrifugal loaders—car pullers—bin level controls, etc.

SEALMASTER DIVISION
A full line of industrial ball bearing units available in both standard and special housings.

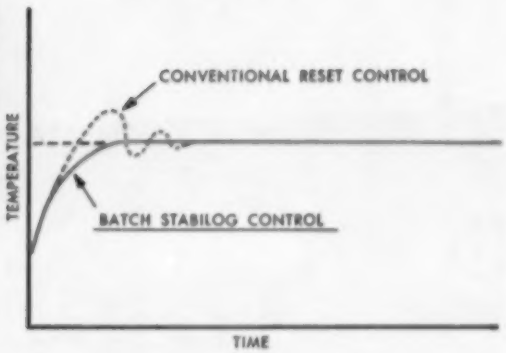
Faster, safer start-ups for Batch Processes

no overshoot

no spoilage

no undesirable side-chain reactions

no explosion hazards



That's right! You can get rid of costly, dangerous temperature "overshoot" problems in batch processing! The Foxboro Batching Controller solves them. This versatile Controller brings temperature up to control point fast . . . stops it "on the nose" . . . keeps it there throughout the holding period. What's more, this fast "no overshoot" control doesn't compromise *holding* control . . . settings are made separately, for optimum results in both periods.

Here's how the Controller works. It starts the operating cycle by feeding maximum heat to the batch . . . brings temperature up fast. At desired distance below control point, adjustable "braking" action automatically slows temperature rise . . . levels it off smoothly at the control point. Simultaneously, the "balancing" action begins . . . holds control point setting exact . . . restores it even when upsets occur. At shut-down of process, the Controller automatically resets itself . . . ready for another precise performance.

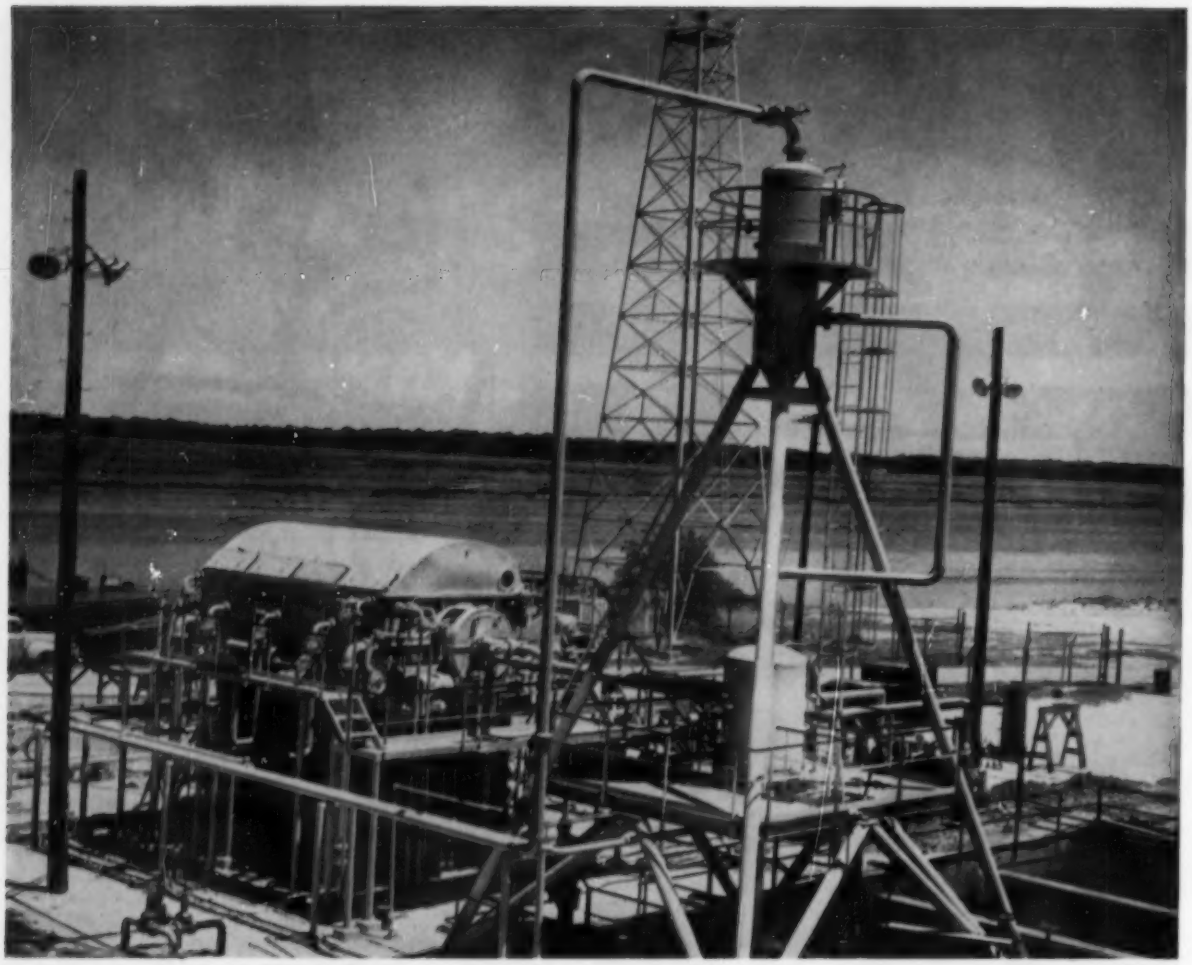
Send for information today. (For batch operations requiring *controlled rate of rise*, write for data on Foxboro Cam-Set and Time-Cycle Controllers.)

The Foxboro Company, 936 Neponset Ave., Foxboro, Mass., U.S.A.

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

FOXBORO
REG. U.S. PAT. OFF.

CREATIVE INSTRUMENTATION for Process Automation



SAVED — 28,734 BARRELS OF OIL IN ONE YEAR!

Slop oil carries values in crude products that can be recovered and sold. The price of a barrel of crude varies with the location of its production and every producing area can use efficient filtration equipment for slop oil, containing waste products from the refinery.

Eimco filters for slop oil do an important job for the industry — in most cases, they not only pay for themselves the first year but yield a handsome profit.

Slop oil filtration is only one application for Eimco filters in the petroleum industry. Clarification and polishing of petroleum products as well as other operations use Eimco specialized filters.

Other special designs of Eimco Filters for vacuum and pressure operation are working in Metallurgical, Food, Drug, Sewage, Sugar, Coal, Chemical and many other fields.

The Eimco Corporation has worked more than half a century to serve the processing industries, providing a background of experience in solving filtration problems which is most valuable to the plant operator. In addition, Eimco's Research and Development Center in Palatine, Illinois is the first complete facilities of its type devoted to liquids-solids separation through filtration.

Facilities unequalled in the industry thus provide Eimco with the "Know-How" to deliver equipment with guaranteed results. An Eimco filter is your assurance of maximum efficiency.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Baltimore, Md. Pittsburgh, Pa. Seattle, Wash. Pasadena, Calif. Houston, Texas Vancouver, B. C. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

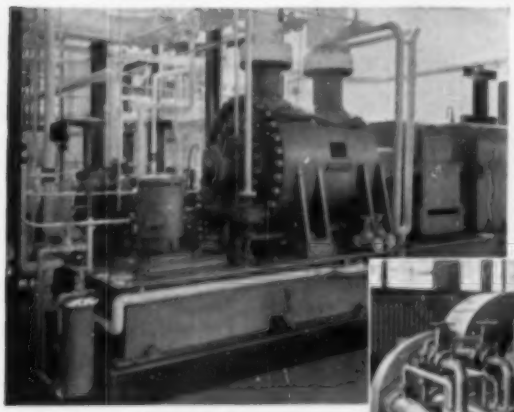
EIMCO

B-190

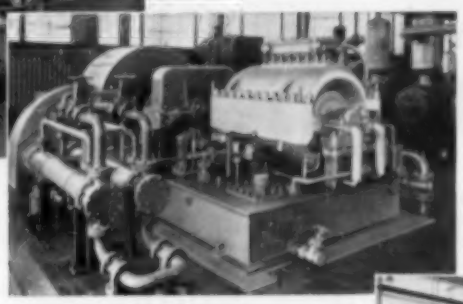
HOW 3 BASIC TYPES OF I-R

CENTRIFUGAL COMPRESSORS

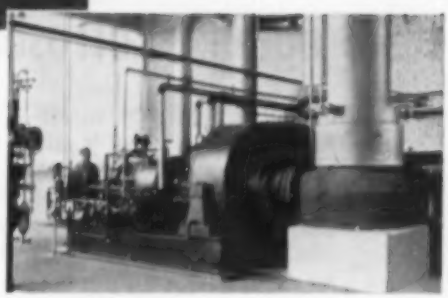
cover practically all of your process requirements



1. MULTI-STAGE VERTICALLY-SPLIT
Capacities to 9,000 cfm
Pressures to 2,200 psi



2. MULTI-STAGE HORIZONTALLY-SPLIT
Capacities to 165,000 cfm
Pressures to 625 psi

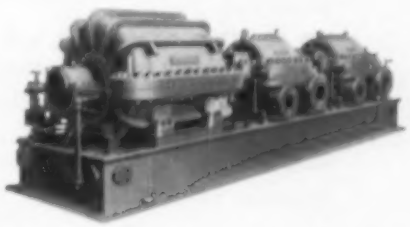


3. SINGLE-STAGE
Capacities to 255,000 cfm
Pressures to 1,000 psi

Here are the three basic types of Ingersoll-Rand centrifugal air and gas compressors. The complete range of sizes available in each type provides extremely wide latitude to meet process conditions. By combining two or more individual units of the same or different types in tandem or in series, a great range of capacities and pressures are obtainable (units up to 2,000 psi have been furnished).

Any type of drive can be used and combination units can be individually powered or driven from a single source — electric motor, steam turbine or gas turbine. This flexibility of application is one reason why more and more I-R centrifugals are being installed in all types of process service.

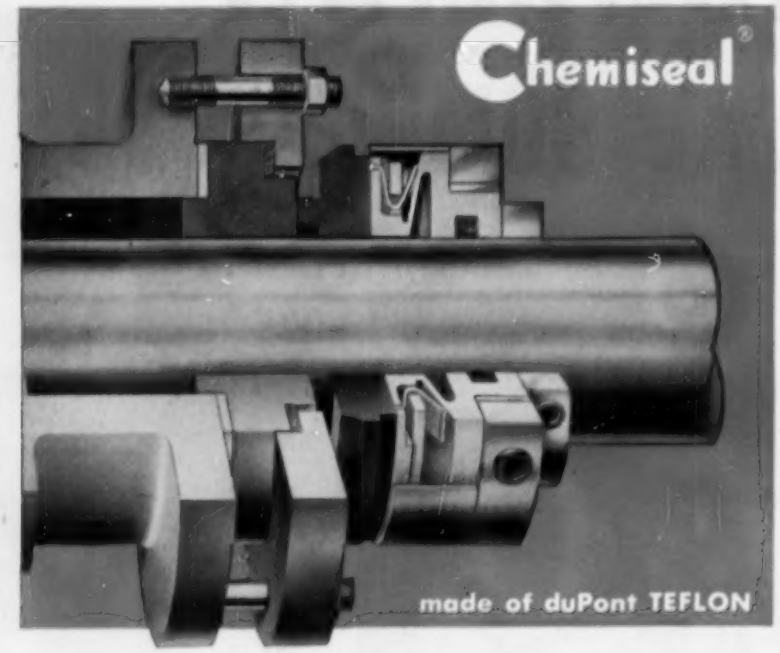
Ingersoll-Rand has supplied more horsepower of industrial centrifugal compressors and Turbo-Blowers than any other manufacturer. This long experience means greater dependability, higher sustained efficiency and less maintenance expense. If you have a process compression problem, call in your I-R engineer. His experience in this specialized field can save you time, effort and expense from initial planning to on-stream operation.



Typical series combination of three multi-stage horizontally split centrifugal compressors mounted on a single base and arranged for a common drive.

Ingersoll-Rand
12-404
11 Broadway, New York 4, N. Y.

COMPRESSORS • GAS AND DIESEL ENGINES • ROCK DRILLS • PUMPS • TURBO-BLOWERS • AIR AND ELECTRIC TOOLS



seal shafts drop-tight against corrosive chemicals

- **UNEQUALED PERFORMANCE**—Chemiseals are handling difficult chemicals . . . acids, alkalies, solvents, hydrocarbons, alcohols, and tarry materials . . . with drop-tight service over long periods of time. Investigate these features:
- **CHEMICALLY IMPERVIOUS TEFLON** one-piece Bellows Section. A selection of seal face materials to suit medium and service requirements.
- **SEAL ROTATES WITH SHAFT.** Only bearing surface is between precision-ground rotating and stationary seal faces. Rotating seal face is molded as an integral part of the Teflon Bellows Unit. Low friction load on shaft. Lower power cost.
- **NO SCORING OF SHAFTS,** and Chemiseals work well on shafts previously scored by other seals or packing.

PRESSURES at the seal up to 100 psi at 75°C or 75 psi at 100°C.

- **SIZES** from ⅛" to 2½". Other sizes on special order.

Maximum length, all seals, 2½".

Ask your U. S. Gasket-Belmont Packing Distributor or write for Bulletin No. MS-1155.

UNITED STATES GASKET CO.
Camden 1, New Jersey

U.S. GASKET • BELMONT PACKING

Noted and quoted

(*Continued from page 18*)

Thanks to Today's Scientist

. . . Today solid scientific tomes are still published in great quantity, but beside them we have what we might call popular scientific works, written by qualified men of science with insight and humor, and couched in a style that he who runs may read. . . .

Appreciation is one thing, understanding another. This is where the work of popular science plays its role. Written by scientists and not by hacks, what makes these books eminently worthy of study is their style, both as to language and presentation. The difficult is made clear and the whole is made palatable to the layman. In an age when science is increasingly entering our life this is important, since it permits everyone to gain some comprehension of the brilliant accomplishments taking place in every field of scientific activity. . . .

Science is not static, nor is its literature. The latter reflects the times, and, one might add, the mental capacity of the reading public. The Victorians may have been of sterner mold than ourselves, indeed, one must often be stout-hearted to read some of their writings. But they were not the only ones to sin in this respect. Many of the classics of science are today unreadable, or are perused merely as curiosities. Science is continually being re-edited, not in the old versions, but in new texts, and more suited to our times. . . .

The popular works . . . touch upon science in general and upon virtually every science in particular. . . .
These popular works of science do not debase the coin of science. Rather they make it common currency for all. . . .

Jacques Ducharme
"Knowledge Without Pain"
in Saturday Review

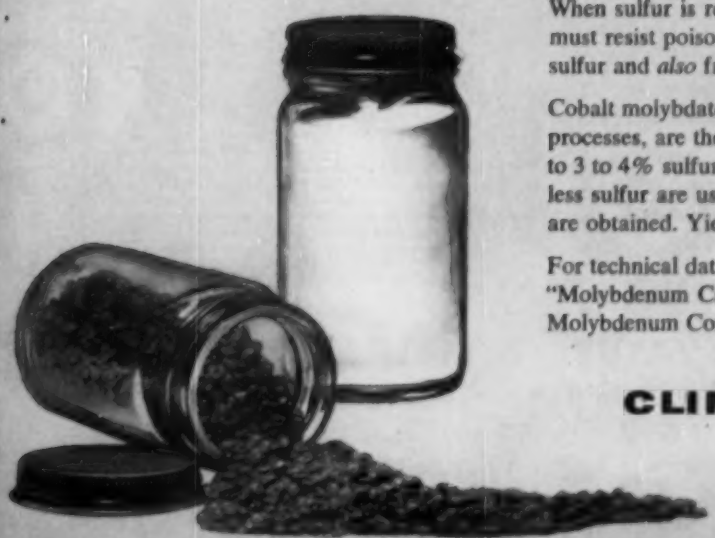
Training Atomic Scientists In Germany

The State Parliament of Baden-Württemberg, in western Germany, has approved a grant . . . ($71,428) for the training of atomic physicists and engineers. The funds will permit the establishment of a professorship in reactor technology and radio-chemistry. Provision has also been made by the State for the construction in Karlsruhe of a technical high school for atomic studies.

(UNESCO)

(*Marginal Notes on page 36*)

Moly catalysts resist poisoning

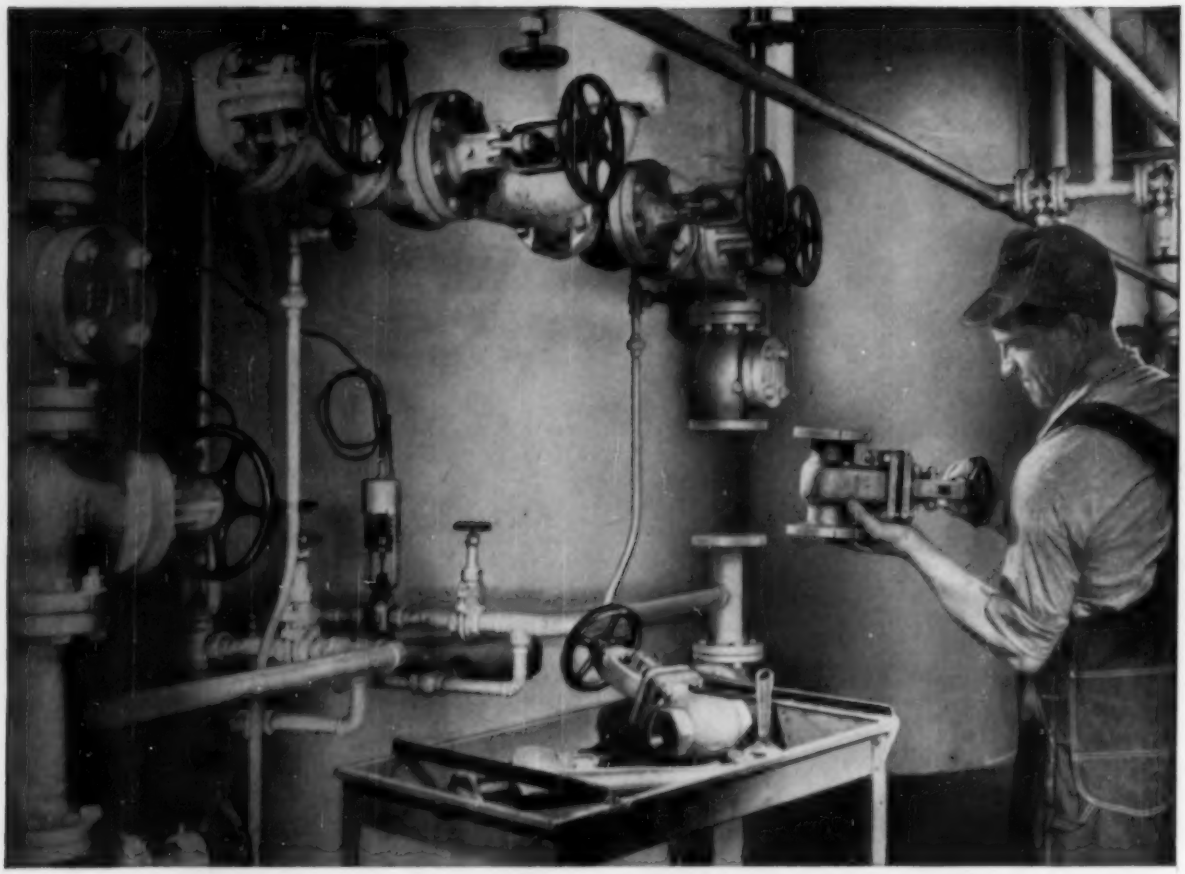


When sulfur is removed from petroleum stocks, the catalyst must resist poisoning. It must withstand contamination from sulfur and *also* from nitrogen and metallic contaminants.

Cobalt molybdate catalysts, in a number of different commercial processes, are the answer to these difficult specifications. Stocks up to 3 to 4% sulfur by weight have been processed. When stocks with less sulfur are used, products containing as little as 0.1% sulfur are obtained. Yields are almost 100% of theoretical.

For technical data about molybdenum catalysts write for our bulletin "Molybdenum Catalysts for Industrial Processes." Dept. 25, Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM



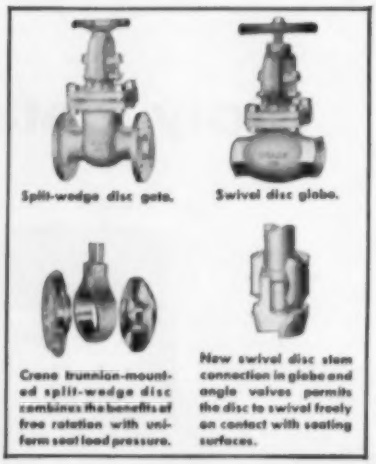
Corrosion meets match in Crane 18-8 SMo and Craneloy 20 valves

It's unanimous! These Crane valves for the process industries were *especially designed* of Crane alloys to cope with costly corrosion and to cut replacement costs.

The gate valves feature a simple, split-wedge disc construction which permits discs to rotate freely within guides and to seat tightly at all points on the seat perimeter. The free movement of the disc, plus uniform seating and unseating loads, minimizes galling and seizing, reduces wear and allows smooth operation under all conditions.

Globe and angle valves now feature a modified plug-type disc that combines the advantages of the easier seating of the narrow ball-to-flat seat and the high resistance of the wider plug-type disc to corrosion, erosion and cutting. In addition, these valves offer a new swivel disc-stem connection that seats the disc squarely every time. Minimum clearance eliminates vibration.

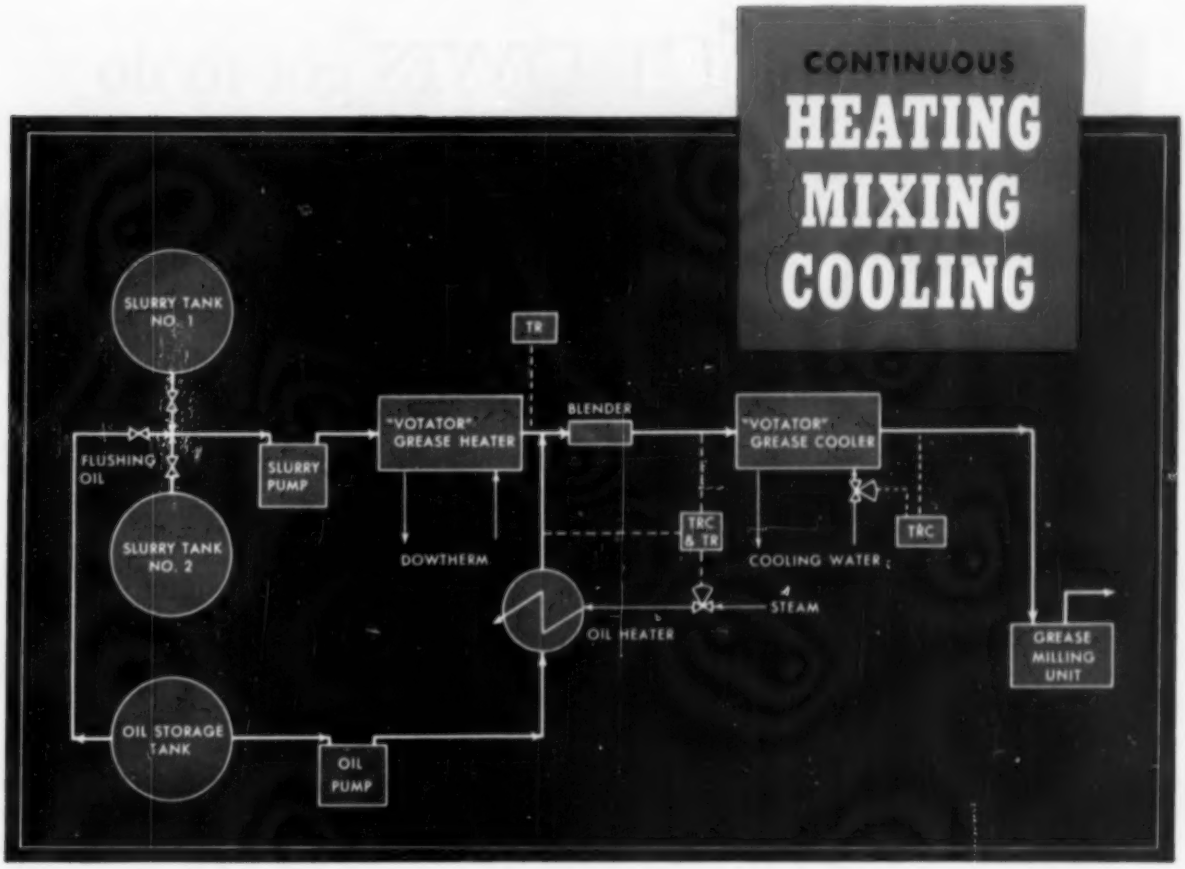
These valves are available in 18-8 SMo and Craneloy 20 . . . in gate, globe, angle and check patterns . . . ½" to 6" . . . screwed or flanged ends. Rated 150 p.s.i. at 500° F.—230 p.s.i. at 100° F. *For more detailed information,* confer with your CRANE representative or write to the address below for the 12-page circular AD-2080.


Split-wedge disc gate.
Swivel disc globe.
Crane trunnion-mounted split-wedge disc combines the benefits of free rotation with uniform seat load pressure.
New swivel disc stem connection in globe and angle valves permits the disc to swivel freely on contact with seating surfaces.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas



How *Votator*® Heat-Transfer Apparatus produces better grease at lower cost

MANUFACTURERS of lithium stearate grease report these important benefits by changing from the open-kettle method to *continuous, enclosed processing* with VOTATOR* Heat-Transfer Apparatus:

- **Higher production rate**
- **Lower labor cost**
- **Lower soap costs**
- **Less floor area required**
- **More uniform consistency and color**
- **No fire hazard—permits use of low-flash oils**
- **Better housekeeping**

Heating, mixing and cooling are performed as shown in the flow diagram. Write today for further information on this profitable processing method. The Girdler Company, Votator Division, 224 East Broadway, Louisville 1, Kentucky.

* VOTATOR—Trade Mark Reg. U. S. Pat. Off.

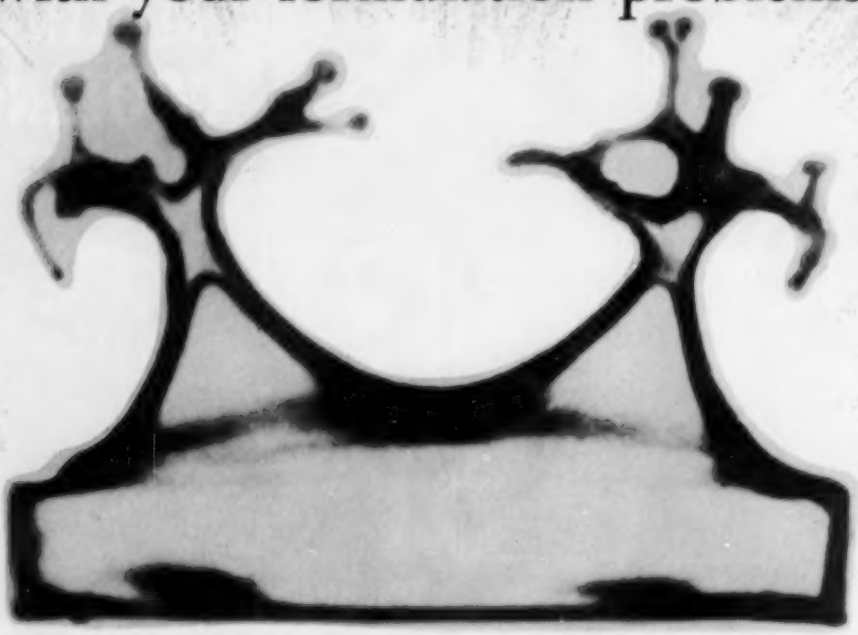
the **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

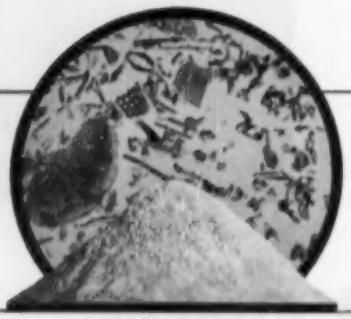
VOTATOR DIVISION: New York • Atlanta • Chicago • San Francisco

What's this "CROWN" got to do with your formulation problems?



This is a particle of Celite diatomaceous earth. The genus is *Dicladia,* species is *Capreolus.* Loosely translated it means "two-sided branch." This particle is just one of hundreds of different intricate particles that together make Celite such an efficient mineral filler. When placed under a microscope *Dicladia Capreolus* becomes a rustic "crown."

It's a particle of CELITE with a cubic foot



The secret of diatomite's remarkable properties—The infinite variety of particle shapes and sizes gives Celite diatomite its exceptional performance characteristics in a wide range of process applications. Irregular shapes like the "crown" prevent packing down for high bulking action.

Johns-Manville CELITE

Cuts cost of formulating insecticide dusts—Celite's extraordinary bulking action allows insecticide formulators to extend poisons for greater coverage from a given weight. Celite also serves as an anticaking agent for this industry.

Controls package loss in cleansers—Cleansers and other powder products remain "fluffed up" after packaging when formulated with Celite. Celite also serves as an absorbent for detergents, wetting agents and odorants.

Adds needed bulk to paper—Because of its exceptionally low apparent density, Celite increases bulk in paper as much as 10% with a corresponding increase in machine speed. Celite is also used in paper mills to control pitch and improve brightness, opacity and ink receptivity.

—the inert mineral filler of bulk in every ten pounds

As much as 10 times greater bulking action than any other mineral filler. That's what you get when you formulate with Celite*. Composed of microscopic irregularly shaped particles of diatomite that won't pack down, Celite contains as much as 93% air space or voids in a given volume. And with its low cost per unit volume, Celite gives you far more bulk per dollar than other mineral fillers.

Many important filler applications are derived from Celite's unique properties. Its light porous mass provides great absorptive capacity, permitting preparation of high concentrate insecticides and other liquids in a dry, free-flowing powder form. The vari-shaped microscopic particles have large surface areas which serve to extend pigments in paint and papermaking. Other important uses include molded plastics, matches, concrete, acetylene tank fillers and adhesives.

Produced from the world's purest commercially available diatomite deposit, Celite comes in a wide range of grades. Each grade is carefully controlled for complete uniformity.

Ask your local J-M Celite engineer to tell you how Celite can help solve your formulation problems. He's backed by Johns-Manville's extensive research facilities and years of practical diatomite experience. Call him today or write Johns-Manville, Box 60, New York 16, N. Y. In Canada, write Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

Industry's most versatile MINERAL FILLERS

JOHNS MANVILLE JM PRODUCTS

ARE ALL YOUR EGGS IN ONE BASKET?

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Marginal notes

Peaceful Uses of Atomic Energy. Proceedings of the International Conference in Geneva, August, 1955, Vol. 14, General Aspects of the Use of Radioactive Isotopes: Dosimetry (1956), published by United Nations; 305 pages. U. S. $6.50; 45/-stg.; 28.00 Swtz. fr.

Reviewed by Henry T. Ward, Professor and Head of Chemical Engineering, Kansas State College, Manhattan, Kansas.

Report of three sessions of the Conference:—Session 7.1: Isotopes in Technology and Industry; Session 19C: General Uses, Production and Handling of Radioactive Isotopes; Session 20C: Dosimetry.

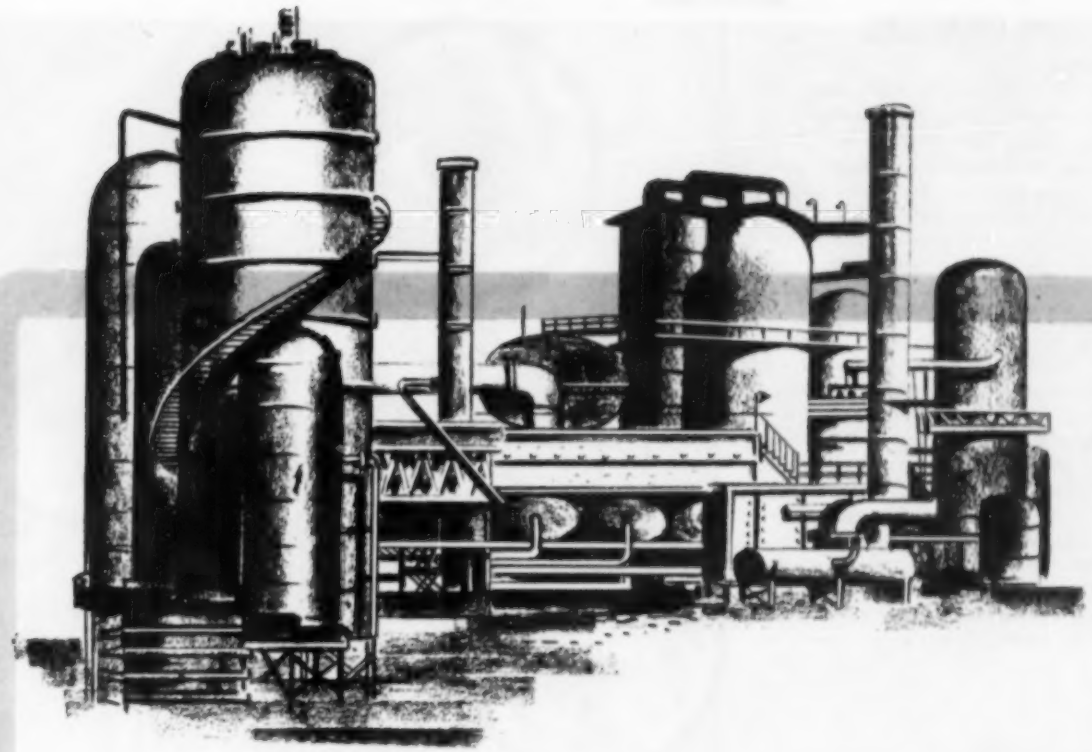
An excellent summary of the importance of radioactive isotopes in technological and industrial applications is given with lists and discussions of specific uses and applications. Outstanding features of the use of radioisotopes are their sensitivity and wide versatility which will cause them, it is anticipated, to become as widely used in routine work as the microscope.

More than 1,000 labelled compounds are available today which are produced in reactors or cyclotrons. One author indicates that the methods for production and handling of Co^{60} are well developed. There are good descriptions of remote mechanical-handling facilities and laboratory layouts.

In the area of dosimetry, articles are presented on the theory and practice of determining radiation dosage either as energy flux or as energy absorbed in some medium. The importance of these studies is demonstrated by the need for evaluating complicated systems of radiations both in regard to quality and quantity of energy. Research in basic science, both physical and biological and in medical isotope applications demands the development of means of measuring specific amounts of beta and gamma radiations and fast and slow neutrons. Low and high level counting instruments are described. Health monitoring, radiocarbon dating, and ionizing radiations are commonly known applications which are reported.

Liquid scintillators, calorimetric measurement of reactor radiations, pulse analyzers, chemical and film dosimeters are described.

(Continued on page 40)



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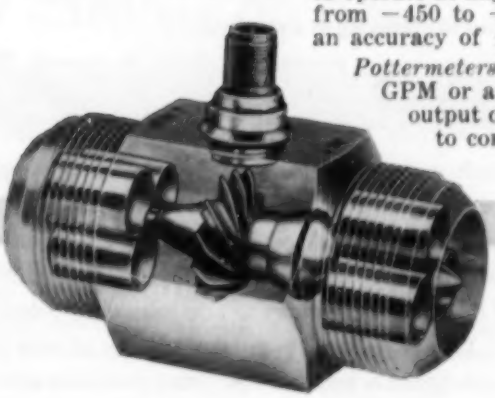
WHETHER you're developing a new process or modernizing an old one—investigate the unique characteristics of the bearingless *Pottermeter*.

This electronic flowmeter—easily installed in any type of piping to operate at any angle, at any pressure and at temperatures from −450 to +1200°F, measures flow of any liquid with an accuracy of ±½ of 1%.

Pottermeters are available to measure flows as low as 0.07 GPM or as high as 3,000 GPM. The inherently linear output of the *Pottermeter* makes it ideal for systems to control either flow rate or total flow.



Find out how the bearingless "floating rotor" used in the *Pottermeter* can give you more precise flow measurement, longer trouble-free service life, and more accurate flow control.

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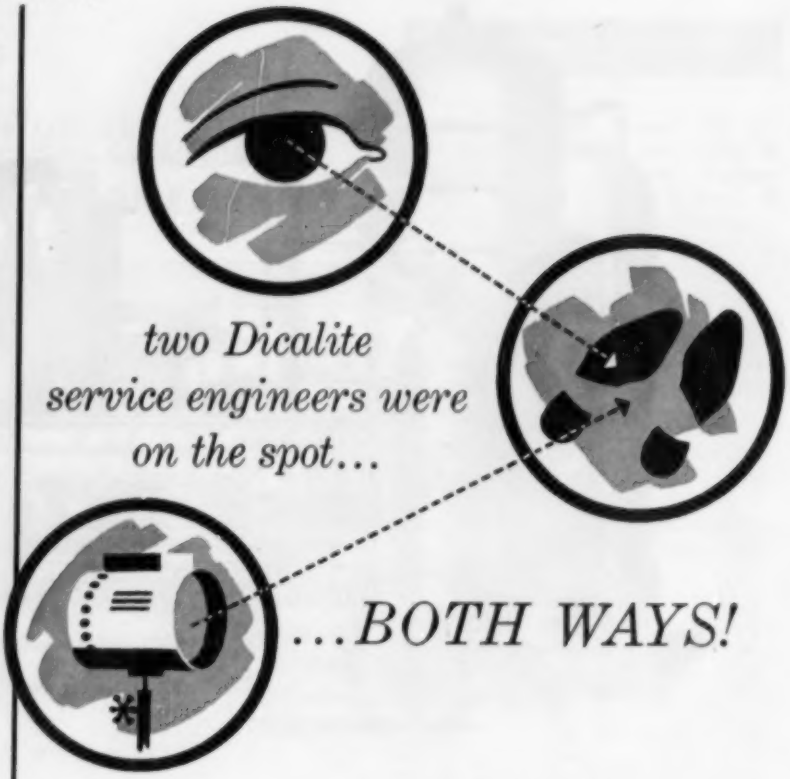
FILTRATION ENGINEERING
—SCIENCE OR ART?

The life of a Dicalite filtration engineer is complicated. He spends much of his time running tests so that he will be able to recommend to a plant or laboratory the optimum grade and dosage of filteraid to attain satisfactory clarity in their particular process liquor. Yet hardly ever can the process engineer of such a plant define the degree of clarity desired in terms of properties which can be precisely measured in a laboratory. Further, the particulates removed by diatomaceous filteraids such as Dicalite are usually of a complex nature, complicated chemically, and troublesome because, as a general rule, their physical characteristics and particle size distribution are unknown. Consequently, when the filtration engineer begins his tests, he is working on the difficult problem of selecting the optimum filteraid without knowing exactly what he is trying to remove, or what precise degree of clarity is required. This explains why filtration engineering is commonly called an art. No mathematical equations for the prediction of clarity exist, despite many years of filteraid research—their formulation, in all probability, must await the development of improved tyndallometers and of stable clarity standards transferable from one laboratory to another. Filtration rates are another matter—Dicalite technicians have well established mathematical relationships for their prediction.

Actually, filtration engineering is an empirical science. Only by actual filtration tests can the selection be made of the proper grade of filteraid and the optimum dosage to obtain maximum throughput consistent with the desired clarity. Experience is an important factor in these tests, since familiarity with thousands of varied filtration systems helps tremendously in charting the most direct course through the many ramifications and possible procedures. Such experience is possessed in high degree by Dicalite service engineers and laboratory staff, among whom are nationally-recognized authorities on filtration. This is probably the reason why, each month, we perform scores of such series of tests for processors and filter manufacturers, either in their own plants or in the Dicalite laboratory. These tests, made without charge, are an important part of Dicalite service, aiding filteraid users to a solution of their problems and, at the same time, contributing to the steady advance in filtration technology.

Paul W. Leppla, *Technical Director*



This problem was a little different from those usually met with by Dicalite's technical service men. A large oil company, working on a new oil additive, had asked if our service engineers could aid in improving an unsatisfactory filtration. So far, an everyday situation. But when the two technical men arrived at the refinery, they found that the importance of the new product had drawn observers from all parts of the company and even from other firms, all deeply interested in the results. It was almost like working in a spotlight.

However, our service engineers produced the answer. They made Dicalite bomb filter tests on the spot, balanced the factors of clarity, throughput and costs. They were then able to recommended a Dicalite filteraid which, in the oil company's own words, "gives us higher clarity and better economics."

While not routine, this is typical of the work of Dicalite's technical service men. They will either work with you in your plant or enlist the services of the Dicalite laboratory to help solve the problem. One way or another, Dicalite answers, each month, scores of such problems—and will be delighted to help you with yours. Just write us.

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But where replacement cost is high, or where contamination through corrosion may occur, the wisest, and in the long run the most economical choice of tubing, is a stainless steel of the correct analysis for the conditions of manufacture and service.

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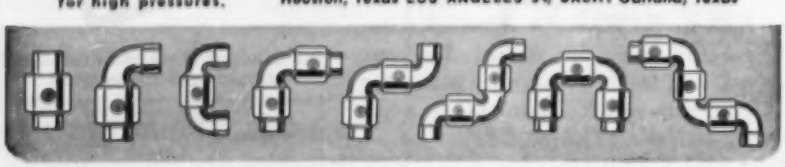


Marginal notes

(Continued from page 36)

A copy of this first fairly comprehensive coverage of this field of scientific development should be in the library of progressive chemical engineers. A glance at the subject titles will help, but a deeper inspection will reveal a fund of valuable knowledge.

Drying and Dehydration of Foods. Harry W. Von Loesecke. Reinhold Publishing Corporation, New York, 292 pages (1955), $7.50.

Reviewed by Purdy Bradford, Swift & Company, Chicago, Illinois

There is probably a wider variation in the type of processing used in drying foodstuffs than in any other processing steps with which a chemical engineer might be concerned. Some of the processes currently in use date back to prehistoric times; many foodstuffs are still dried by exposing food to the rays of the sun. Some products are dried with the most modern type of drying equipment such as large capacity spray dryers. In the second edition of his book, Mr. Von Loesecke also discusses the various processes employed in drying different types of foods.

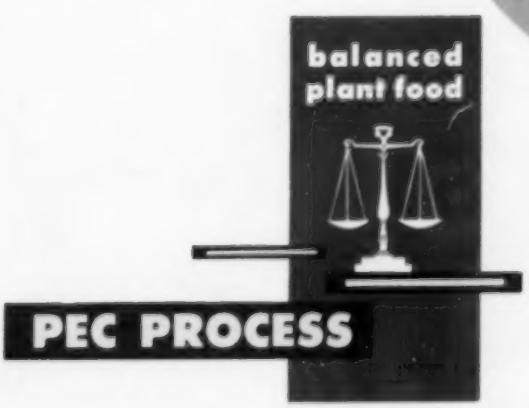
This book is meant neither to be an all-encompassing text on the drying of food materials, nor does it contain a large amount of detailed information on the design and operation of various types of dryers. What it does contain is a short concise description of the many processes used for the preparation and drying of a host of different products of farm, orchard, or sea. Crammed into its rather limited space is a wealth of information on the types of equipment and the conditions used today in drying almost every type of food which appears on the market in dried form—vegetables, fruit, meat, fish, eggs, milk, butter, cheese, and other types of food are all covered in a limited but satisfactory manner.

At times, one might wish that the author would spend more time on various problems encountered in the drying of foods, but the extensive bibliography refers one to most of the pertinent technical literature on the subject. The author has managed to reproduce considerable information in the form of tables and graphs so that this is available in one place. Much of this information is not easily accessible unless one is working in the particular field in question.

(Continued on page 46)

complex fertilizer

C & I



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An unusual plan is now in effect, to quickly help you throw production into high gear—even on a new process.

Standard designs of reaction kettles, tanks, heat exchangers and other Pfaudler equipment have been worked out to include many of the most-wanted features of custom-built equipment, such as a variety of openings on reactor heads, and removable tube bundles in heat exchangers.

A stockpile of these standard-design units is built up, enabling Pfaudler to quickly meet your needs for standard equipment.

How this toothpaste company rushed new product to market

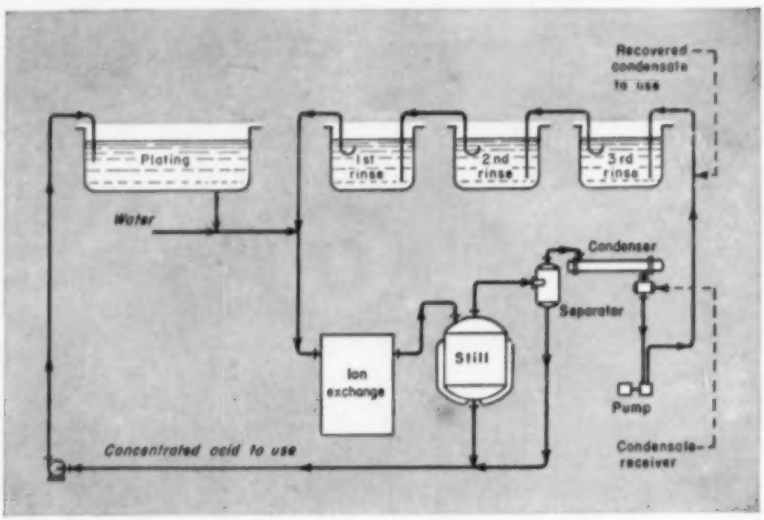
After exhaustive tests, one of America's biggest toothpaste companies decided to add a new ingredient to its product. The problem was to get the new product on the market as quickly as possible. The answer: by selecting standard designs, they got fast delivery of several huge Pfaudler glassed steel reaction kettles—direct from stockpile to their plant!

Polio vaccine producer got new kettle before written order was received!

Strange as it sounds, a glassed steel kettle was shipped to a producer of polio vaccine *before* Pfaudler received his written order! Recognizing his urgent need, the Pfaudler representative helped him select a standard design which would quickly increase his production. The order was telephoned. Within 10 days the equipment was on its way!

Standard Pfaudler glassed steel reactors (30 to 2000 gallons) are designed to meet a wide range of operating requirements, are stocked to make quick deliveries possible.

How to rescue $11,900 a year in waste acid



Flow chart for plating-plant operation, including plating and rinse tanks, ion-exchange, and recovery system.

If you plate with chrome, nickel, copper, silver, or gold, you can save up to 80% of your plating acid, with consequent savings of thousands of dollars a year.

A study of 30 leading plating companies revealed that a Pfaudler recovery system with a 500-gal. still could save an average of $11,900 a year, by removing water from dilute acids in the waste and providing a concentrated acid solution of plating strength. The system also returns the recovered distilled water to the rinse baths—a further saving.

Saved $42,000

In the midwest, a large user was losing 80% of his chrome acid down the drain. This was considered a reasonable record in the industry, but by installing a Pfaudler recovery system the company cut its waste tremendously, saving $42,000 a year!

Pfaudler recovery systems prevent the loss of the acid itself, and eliminate the need for chemically treating waste liquids to meet anti-pollution statutes.

Of tremendous importance in a system of this type is the material of construction used in the equipment. The hot, concentrated acid solutions are corrosive and might attack the equipment, contaminating wash water and making it unusable. To meet the rigid corrosion requirements of such solutions as 25 to 45% chromic acid, the Pfaudler system uses a glassed steel still and receiver. For other parts of the system, high-grade stainless steel units provide the proper protection.

Glassed steel provides a high range of corrosion resistance, allowing you to recover solutions of widely varying strength or content. It resists attack by all acids except hydrofluoric, and by alkaline solutions to pH 12 and 212° F.

If you plate with silver or gold, glassed steel provides an additional advantage. It prevents immersion deposits from forming as they might on steel vessels.

Several systems are offered as "packaged" plants—completely engineered, fabricated and delivered by Pfaudler ready to operate. You can operate by batches, semi-continuously, or with a fully automatic continuous system. Capacities range to about 2100 gallons per 8-hour day.

Further details on request.

NEW TREND IN AMMONIA PLANTS

LUMMUS' 60 T/D UNIT FOR WESTVACO

One of the least expensive ammonia plants ever built went on stream in October 1955 at the South Charleston, West Virginia plant of the Westvaco Chlor-Alkali Division, Food Machinery and Chemical Corporation.

It is a small, automatic unit designed to operate with a labor force of two operators per shift, and produce 60 tons per day of anhydrous ammonia from waste chlorine cell hydrogen. Carefully designed and engineered for low investment and low operating costs, and incorporating all the latest safety features, the plant will have an unusually short payout time.

This small, minimum investment unit may well be the prototype for agricultural and industrial ammonia plants of the future. Because ammonia cannot be shipped over long distances, many such units, properly placed at hydrogen, natural gas, fuel oil and other sources throughout the country, would conveniently serve limited local areas.

Lummus built the plant around existing Westvaco facilities in an extremely confined area (as shown in the above photograph) without interrupting any normal plant operations, yet completed the job ahead of schedule in a brief seven months, with an excellent start-up. Westvaco was pleased with the job all along the line, from idea through operation.

This is one of four ammonia projects by Lummus in the last two years, and adds another to the 700-plus major installations completed by Lummus throughout the world.

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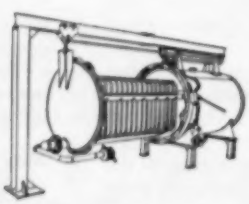
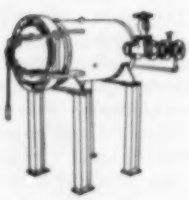


HORIZONTAL LEAF FILTERS



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the only (repeat-ONLY) plastic rotary pump

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"Flex-i-liner" pumps are furnished in these materials:

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Buna N—"N" Series—High temperature resistance and suitable for use with weak acids, strong alkalies, vegetable and mineral oils. Recommended for such typical applications as: Plating Solutions, Chemical Salt Solutions at elevated temperatures; Petroleum Products; Tuna Fish Oil; Shortening; Ferric Chloride and Tile Glaze Slurry.

Bakelite—"B" Series—Excellent for organic solvents and organic acids. Good for weak acids and alkalies. Recommended for such typical applications as Acetic, Formic and Oleic acids; Ethyl and Methyl Alcohol; Carbon Tetrachloride; Gasoline, Kerosene, Fuel Oils; Photographic Solutions and Glycerine.

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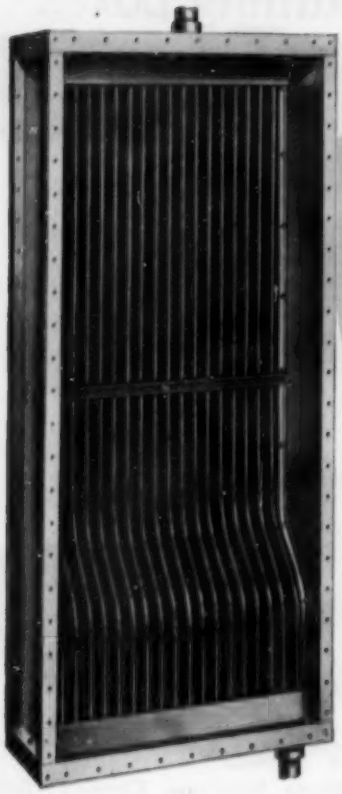

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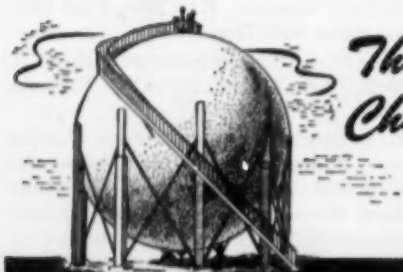

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Marginal notes

(*Continued from page* 40)

This book contains much more information than the limited number of pages suggests and it is a valuable addition to the library of one working in the food field.

The Principles of Chemical Equilibrium. K. G. Denbigh, Cambridge University Press, 491 pages (1955), $7.50.

Reviewed by J. M. Smith, Professor of Chemical Engineering, Purdue University, Lafayette, Indiana.

The first of the three parts of this book is concerned with the laws of thermodynamics. thermodynamic functions and their interrelationships. Next comes the largest section dealing with phase- and chemical-reaction equilibria for gases, liquids, and solids. The third, and most novel part, is a short introduction to statistical mechanics with applications to gases, solutions, perfect crystals, and chemical kinetics.

The level of presentation is such that a good background in the first and second laws is required for proper understanding of the material. In this country the book would be suitable for students at the graduate level.

The first and second laws are handled in an adequate manner and the historical development of the concept of energy, particularly Joule's experiments, is a welcome feature. However, the basic concepts are, on occasion, somewhat obscured by the amount of detail used to make the definitions fit many special cases and still be rigorous. For this reason the material may not be as suitable for students as for instructors and specialists in the field.

The molecular interpretation of the second law is an excellent feature. The concept of mixing on the molecular level and its relationship to probability add considerably to the section on the first two laws.

The second part of the text begins with a discussion of the chemical potential and then goes on to the conditions of equilibrium. The development follows closely that of Gibbs. Vapor-liquid equilibrium is treated for both ideal and nonideal solutions and the application of the Gibbs-Duhem equation is discussed. Some of the practical methods of correlating phase-equilibria data such as the Van Laar and Margules equations are included, but this treatment is not complete. For example, no mention is made of the significant work of Redlich and Kister. This com-

(*Continued on page* 48)

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Marginal notes

(*Continued from page* 46)

ment can be applied in general to the whole book. The principles are presented for each area, but the practical applications are limited in extent. Thus in the treatment of the P-V-T relations of gases, Van der Waals' and the virial equations of state are mentioned, but advances based upon the law of corresponding state are not included. From this point of view the book follows the typical chemical thermodynamics treatment more closely than the more practical chemical engineering approach.

In the third part of the text Schrodinger's wave equation is presented and then the concept of the partition function developed. Applications to perfect gases and perfect crystals are considered. Particularly interesting are the derivations of the Langmuir's adsorption isotherm by a statistical method and the thermodynamic analysis of the absolute theory of reaction rates. This section will be of value to those chemists and chemical engineers who are in search of a brief but readable statistical background to thermodynamics.

A helpful inclusion at the end of the book is an Appendix discussing the method of solving the problems listed after each chapter. Answers to the problems are also given.

The College Blue Book. Christian E. Burckel, editor and publisher, Yonkers-on-Hudson, New York, 688 pages (1956), $12.

This volume is a compendium of information about institutions of higher learning in the United States requiring graduation from a secondary school for admission. It includes a section on engineering schools by W. Leighton Collins, Secretary, A.S.E.E., and lists the engineering curricula accredited by E.C.P.D. Other sections of particular interest to engineers are devoted to technical institutions and to scholarships, foundations, and research. This eighth edition replaces the seventh edition printed in 1953.

Books received

Elements of Quantitative Analysis, 4 ed. Hobart H. Willard, N. Howell Furman, and Clark E. Bricker. D. Van Nostrand Co., Inc., Princeton, N. J. (1956), 576 pages, $5.85.

Fundamentals of Qualitative Chemical Analysis, Semimicro Method, 4 ed. Roy K. McAlpine and Byron A. Soule. D. Van Nostrand Co., Inc., Princeton, N. J. (1956), 340 pages, $5.00.

About our authors

Happel Wins a Tyler Award

John Happel, professor of chemical engineering and chairman of the department at New York University, has won a Stephen L. Tyler Award for his article "Venture Worth Method for Economic Balance" published in *C.E.P.*, December, 1955. Howard Malakoff was chairman of the judging committee.

This award is made by the New York Section of A.I.Ch.E. each year for the best published article or book written by a New York Section member.

Because of the excellence of a book published by another section member, Prof. Robert E. Treybal, also of N.Y.U., the Award was also presented to him. A full report on this appears in the Local Section News in this issue of *C.E.P.*

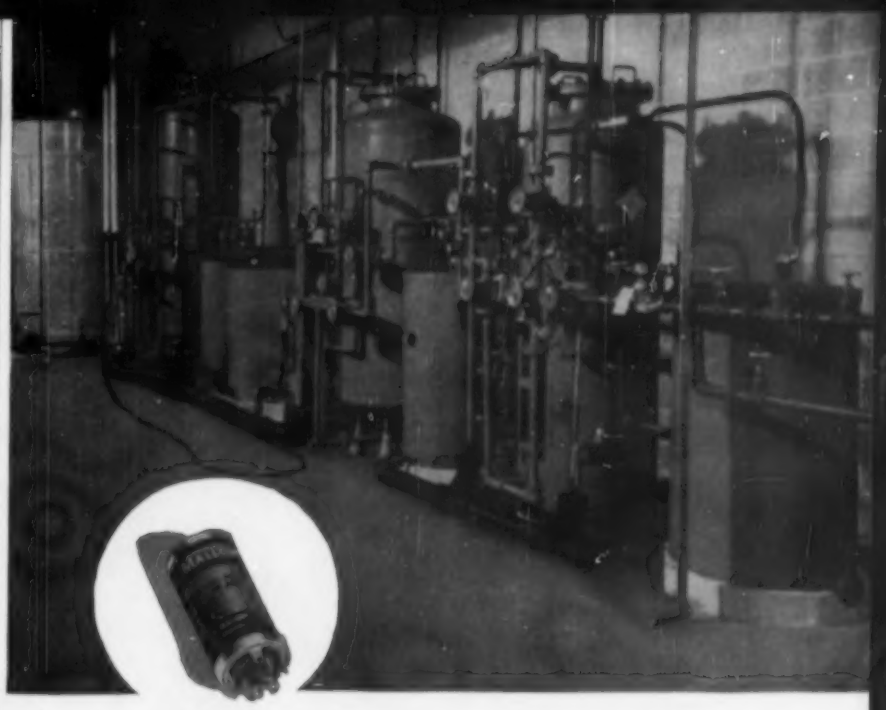
Stephen L. Tyler presenting award to John Happel.

Happel's article represented a condensation from the voluminous text of an evening lecture series given before members of the New Jersey Section in the Spring of 1955. When John first introduced his thoughts of producing an article out of the immense bulk of speaking manuscript, it seemed to us to be a truly monumental task. Perhaps there is a moral to this story—something to the effect that condensation needn't hurt any really good manuscript text!

Pressburg's Presentation Best at N. O.

Bernard S. Pressburg, professor of chemical engineering at Louisiana State University, was judged by a special committee as having made the best presentation of a paper at the recent New Orleans National Meeting.

Pressburg's paper was entitled "Heat Transfer Coefficients for Condensing Organic Vapors of Pure Components and Binary Mixtures." With heat transfer as his principal research interest, Pressburg has been a member of the staff of L.S.U. since 1941.



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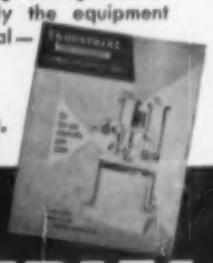

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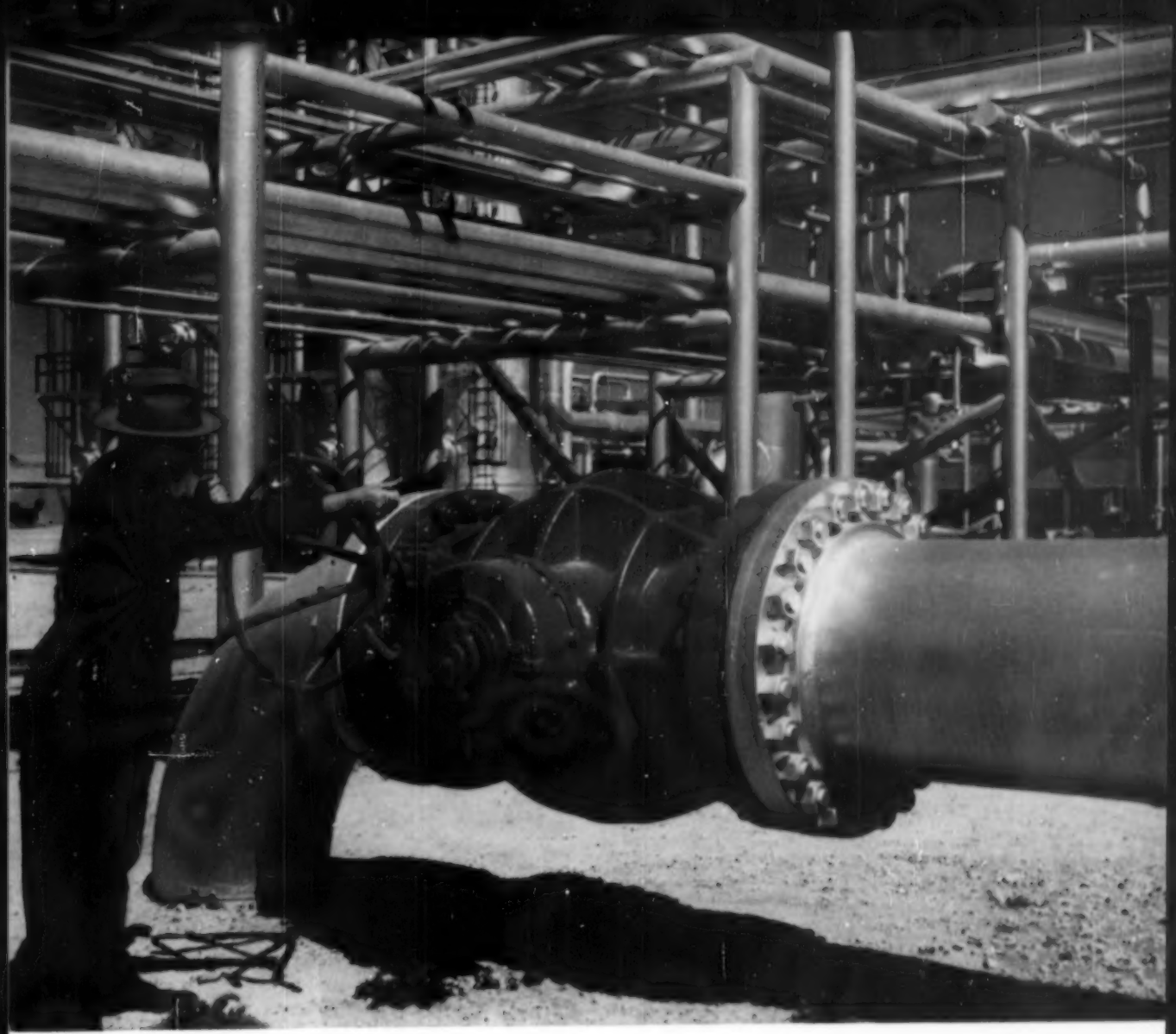

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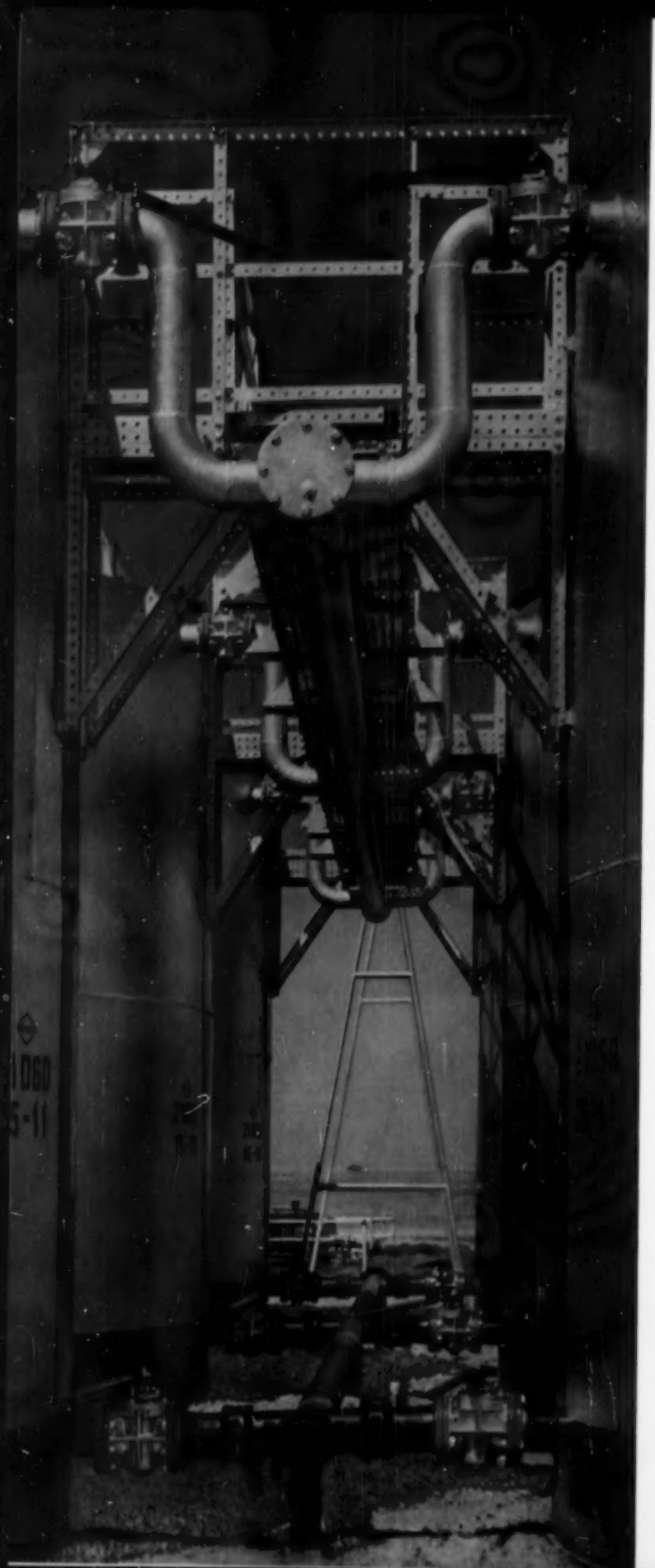

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Although a number of industry segments have been soft in recent months, chemical business has been holding up extraordinarily well during the current quarter.

Declines in sales in some fields have been offset by better business in others, with increased plant capacity an important factor. Chemical expansion is taking place largely in fields where markets are still unsaturated so that new capacity can usually be sold even when general business slips a little.

Such major firms as Allied, Union Carbide, American Cyanamid, Hercules Powder, and Dow expect to report earnings in the current period about as large as in the first quarter, which set a number of new records. Dow, according to talk in financial circles, had one of the best months in its history in May.

Consumer Soft Spots

Soft spots in chemical consuming industries include the huge motor industry, the textile industry, and the fertilizer industry which buys phosphates, nitrates and a diversity of insecticides and weed killers.

The textile industry has for months been one of the sickest divisions of business. Since it is one of the largest consumers of chemicals of all kinds, it is a tribute to the diversification and resourcefulness of chemical firms that their operations have shown so little reaction to the difficulties of one of their major outlets.

The rayon industry has been particularly hard hit. During the last half of last year total production of fabrics made from rayon filament yarn was reduced 20%, output of cloth made from short staple rayon dropped about 25%, and the situation has become somewhat worse since then. From a poundage viewpoint the synthetic fibers are small compared to rayon, but the situation is comparable. Some time ago Du Pont made price cuts in its synthetic fibers in an effort to stimulate sales volume.

The rubber industry has also been soft, along with the automobile industry, which naturally affects rubber processing chemicals. However, there is a ray of hope for an unseasonal pick up during the summer months, based on reports that several of the large motor firms plan to switch from 15- to 14-inch diameter wheels. If this materializes it would require large production of new tires by the rubber firms both to equip new cars and to fill pipe lines for dealers.

Headlines lately have stressed cutbacks in the motor industry, a major consumer of lacquers, finishes, plastics, synthetic textiles and other chemically based materials. Here again the diversification of the chemical industry becomes apparent. One major maker of finishes and plastics for the motor industry reports that its sales of finishes are currently off less than 5%. This firm expects little change in its earnings in the second quarter from the record first quarter, even allowing for dips in the business of some of its big consumers.

Agricultural Chemicals

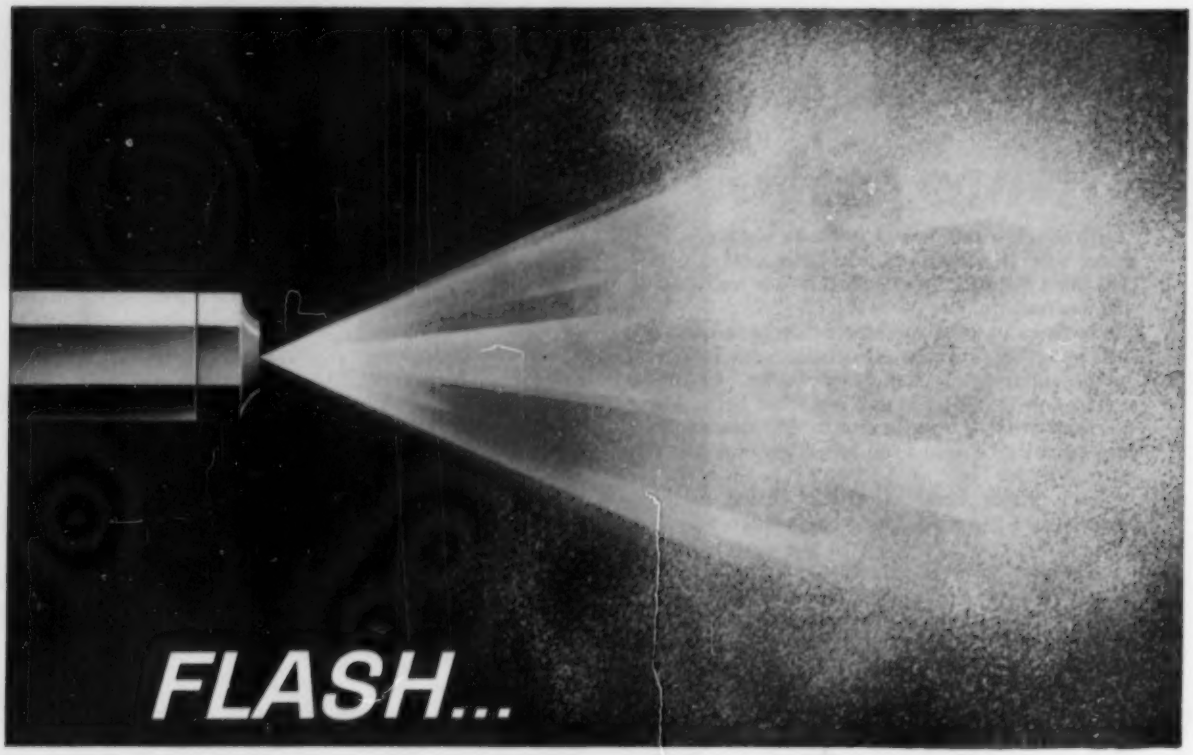
One gloomy spot in the chemical picture is in plant foods, notably in ammonia and nitrates, which have had a huge expansion in capacity in the last few years—a program that is still continuing. Phosphate producers, which include the leading plant food companies, are used to the ups and downs of the farming business, but the makers of ammonia are chemical firms, accustomed to more stable markets and prices and a number of these firms, particularly smaller and newer producers, are beginning to feel the pinch.

So far there have been no open cuts in ammonia prices, but production is up and sales are down, indicating possible development of price cutting. On the cheerful side is the fact that the farmer is moving toward the use of more fertilizer per acre and over the next few years will probably take up the surplus ammonia production.

Inorganic Renascence

One trend in the chemical industry that should be kept in mind by those who are looking ahead is the renascence in inorganic chemicals, with particular emphasis on the new metals and their compounds. For reasons that are obvious, the new metals are in the chemical industry's province because they require chemical techniques. Leading firms in the field of magnesium, titanium, zirconium, boron and lithium are almost all firms in the chemical group. Most of them got into the field through early knowledge and know-how of chemical compounds rather than of the metals themselves.

This trend will not only have the effect of widening chemical horizons, but may well enlarge markets for other chemicals. A spokesman for Hooker Electrochemical Corp. has lately pointed out that an important factor in future chlorine demand is the growth in titanium and zirconium; if demand for these metals reaches projected estimates and if current processes are used, the chlorine demand could be "tremendous." But beyond these two metals alone there are important possibilities in other metal chlorides and fluorides. There is a great deal of experimental work and interest in boron compounds for jet fuels as well as for additives to motor gasoline. One way to make these compounds is through boron trichloride, and if this idea materializes, another chlorine market might unfold.



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ASK FOR BULLETIN NO. 373

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opinion and comment

Opportunity Abroad

THE world abroad, particularly Europe, abounds in opportunities both for those who wish to sell the products of our chemical process industries, and for those who may want to acquire technological know-how. At least this was the consensus of three "foreign affairs" chemical industry specialists addressing a symposium at the New Orleans National Meeting.

Our annual chemical exports now amount to $1 billion—big business by any standard. This represents a growth, according to J. C. H. Stearns of Dow Chemical International, which started from a mere $127 million in 1938, the last full pre-war year, and has since shown an 8-fold increase, which compares well with the 5-fold growth for all U. S. exports for the same period.

Chemical imports have increased from $77 million in 1938 to $250 million in 1954. Their growth has not been as great as that of exports, however. In 1938 our imports were 61% as great as exports, but in 1954 only 25% as great.

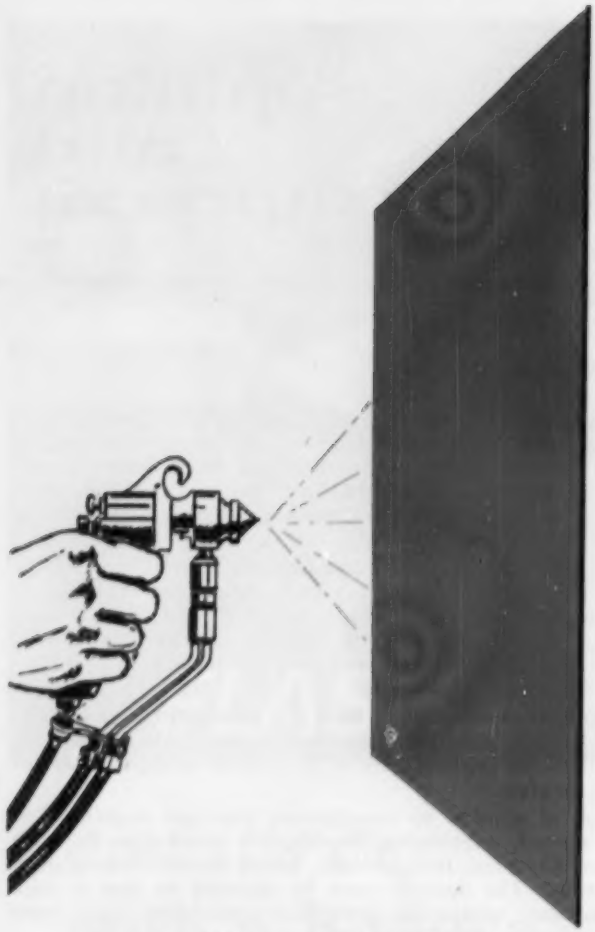
The question of whether to manufacture here and export, or to manufacture abroad, underwent considerable discussion by both Stearns of Dow Chemical International, which started from a mere no simple answer. The decision must by necessity be tied in with experience, currency restrictions, personnel availability, local taxes and social legislation, and other factors.

Among important aids to U. S. firms desiring to manufacture abroad is our I.C.A. Investment Guaranty Program, inaugurated within the past few weeks. This protects American companies against currency inconvertibility and expropriation, but offers no insurance against failure to make a profit, warned Binney. Another aid involves U. S. Treasury loans of foreign currencies to U. S. firms for plant construction abroad. This money comes from funds taken in by our government through the sale of surplus agricultural commodities under Public Law No. 480. Still another convenience is the possibility, within certain nations, of setting up "profit sanctuary" holding companies which serve as repositories for funds which otherwise, if returned to this country, would be subject to tax as earned income. Sometimes these holding arrangements only defer the payment of such tax, but this depends on whether the funds are reinvested abroad rather than ultimately returned.

Not all opportunities abroad have to do with commerce. According to A. H. Schutte of The Lummus Company, European technology has not only staged a comeback, but, at least in some subjects, a major advance. Chemical productivity growth in Europe has increased (from 1951-54) as follows: France 18%, U.K. 27%, W. Germany 48%, and Italy 56%. Schutte believes that many underdeveloped nations of South America and other continents will be striving to get major production facilities of their own—for improving their internal conditions—and that we should be prepared to meet competition in providing these facilities.

As to foreign technological developments, one of the most recent of which is polypropylene, Schutte offered this advice: "maximum progress will be made by developing, sure—but also by adopting what has already been done—and adapting it to our needs—by swapping experience and intelligently applying it to the job in hand."

J.B.M.



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During the past twenty-five years tremendous advances have been made in measurement and control techniques. In the early days of instrumentation hand control of process variables was used almost exclusively. However, as processes became more complex, it became more difficult to hand-control the variables and the initial automatization of processes occurred.

Within the past year special interest has been evidenced in automatic logging and computation systems. This paper describes a typical system and emphasizes particularly the solution of various problems encountered in design.

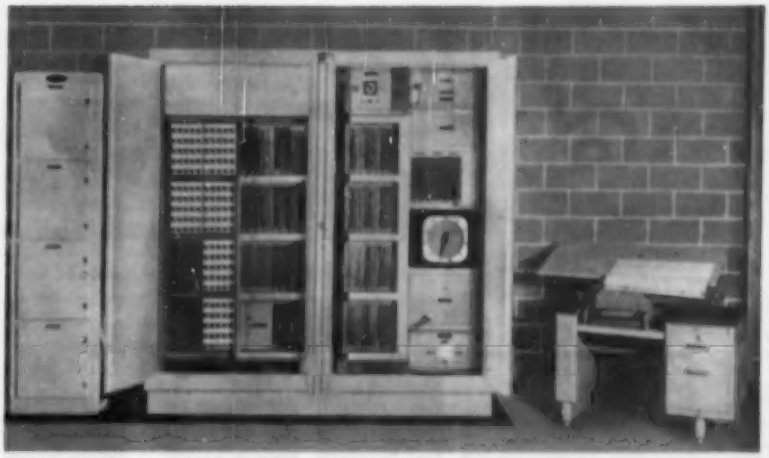


Fig. 1. Typical equipment arrangement of the automatic logging system within a centralized control room.

AUTOMATIC logging and computation system

Robert J. Marmorstone | Panellit, Inc., Skokie, Illinois

As more and more instruments have been required due to the expansion and complexity of modern processes, centralized control and miniature instrumentation have become necessary. A logical solution to the problem of efficient operation and supervision is the advent of the graphic control panel (*2*), which presents pictorially the process being controlled. Frequently the picture is in the form of a simplified diagram of the process. Major equipment pieces are shown by appropriately shaped symbols or mimic busses of the proper relative size. Major process flows are represented by lines of various colors and widths. Recording and controlling instruments are usually of the miniature type and are placed on the flow diagram, clearly indicating the location and specific variable to which they apply. Visual and audible alarms serve to call immediately the operator's attention to any abnormal conditions of the process variable.

Information is the foundation upon which the science of automatic control is built. In order to put a machine or process under effective control, there must be sufficient information available to characterize its operations. After this information is converted into a visible form, it can be compared with predetermined criteria, and corrective action can be applied to achieve the desired status when abnormal process variables are indicated.

Automatic logging opens the door to more accurate accumulation of data in the laboratory and in industrial processes. Immediate evaluation of process variables can be achieved since the need for tedious manual logging, with its inherent transposition errors, is eliminated.

Gains result also from immediate computation in terms of over-all efficiency increase in plant operation. The employment of punched tape in conjunction with the logger makes possible the utilization of data in computers.

The Basic System

An automatic logging system periodically scans a large number of process variables (pressures, temperatures, flows, etc.) and prints and arranges the process variables in a manner where this information can be quickly and efficiently reviewed by an operator. Figure 1 illustrates a typical equipment arrangement of a logging system within a centralized control room.

Figure 2 categorizes the components of a logging system into its basic building blocks, showing these blocks in functional form.

Transducers: By definition a transducer or primary measuring element is a device for converting one type of physical phenomenon into another type. In the specific system here described the initial physical phenomenon takes the form of a temperature, pressure, or flow. Conversion must be in the form of a suitable electric signal—a change in voltage, current, or resistance.

Sequential Switching System: This system usually consists of electrically operated stepping switches, relay trains, motor-driven switches, or electronic scanning devices.

Measurement System: Two types of measurement systems are in common use: the first utilizes the null-balance potentiometer principle wherein the input voltage is measured against a known slidewire voltage; the second is electronic in design wherein a time-varying reference converts a voltage level to a time difference. In the latter case the time is proportional to the input voltage.

Analog to Digital Converter: This component consists of any suitable electromechanical or electronic device which converts a physical quantity, such as a shaft position, to a digital output.

Code Conversion Matrices: In the logging system the relay or diode matrix converts the output code from the analog to digital converter to a code suitable for actuation of the electric typewriter.

Alarm Detection: Basically, alarm detection is an electronic difference circuit

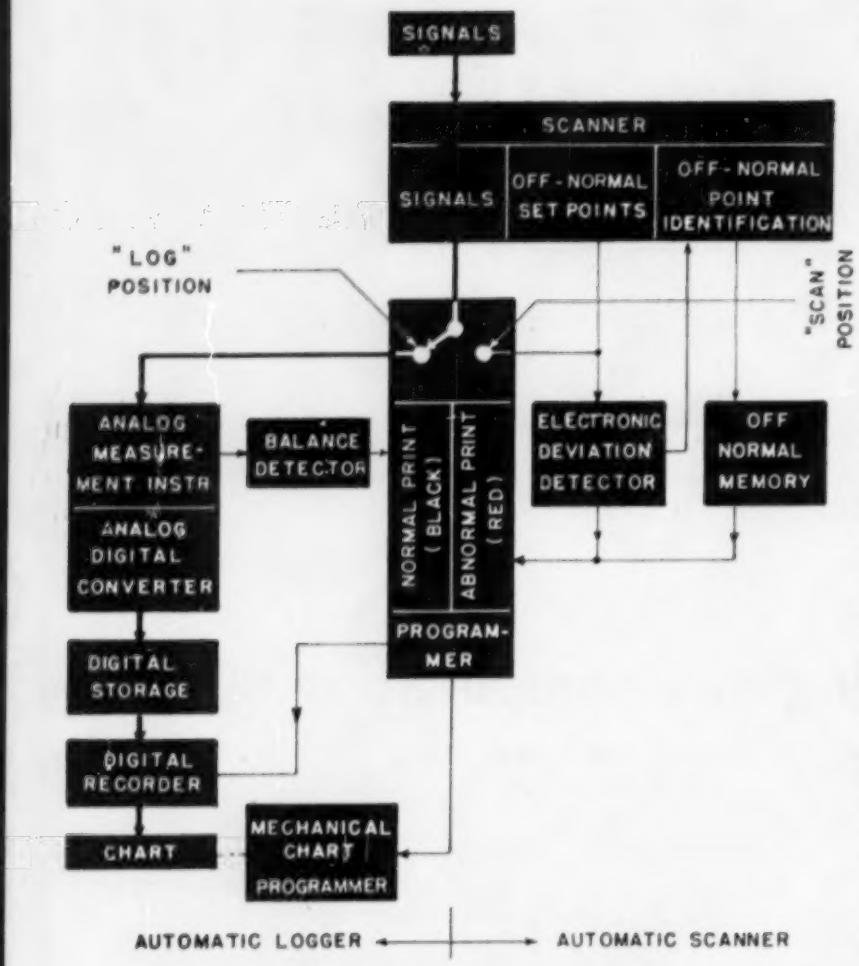


Fig. 2. Basic component building blocks of logging system.

which compares the input signal to a predetermined reference voltage.

Digital Clock: A digital clock consists of any suitable time accumulator which has provision for electrical readout of the time.

Programmer: The programmer consists of several basic subdivisions which control the operation and interlocking of the entire system. These subdivisions may be broken down into print, chart, and test programmers.

Alarm Memory: In order to prevent repetitive printing of an alarm, it is desirable to print only the time the particular point goes "off-normal" and the time at which it returns to normal. With this kind of operation some type of alarm memory is required. Memory may take the form of a latch relay, capacitor, or toroid coil.

Electric Typewriter: Any standard electric typewriter or teletype machine can be operated from an automatic logging system, provided it has the proper analog to digital converter.

Primary Measuring Devices

TEMPERATURE MEASUREMENTS

Thermocouples: Thermocouples are the most common type of temperature measuring elements. Temperatures ranging from approximately −300° F. to +3,000° F., can be accurately and dependably measured with thermocouples.

Thermocouple voltages are so small that the electrical input signal must be amplified before the input voltage can be converted into digital form. A common method of amplification is accomplished through the use of the null-balance potentiometer. Figure 4 presents output millivolt curves for iron-constantan and platinum-platinum−10% Rh thermocouples. Since these curves are typically nonlinear, some provision must be made to linearize these analogous voltages. Linearization is accomplished readily by means of cams and tapped or tapered potentiometers if the analog input is available in the form of a shaft position. Figure 5 illustrates a typical cam and cam follower used in conjunction with a linear slide-wire.

Resistance Thermometers: Like the thermocouple, the resistance thermometer has the advantage of measuring temperatures in relatively inaccessible places and transmitting the results over electric wire (*4*). Resistance thermometers are used generally for measuring relatively low temperatures. The nominal range of a high-speed bulb is usually from −20° F. to +300° F.

One basic problem presents itself with the introduction of the resistance thermometer as a primary measuring element. Thermocouples and pressure and flow transducers are basically two-wire elements that may be switched readily by two levels of a standard rotary stepping switch. However, the resistance thermometer requires a three-wire circuit since one wire is required to eliminate ambient-temperature change effect upon lead circuitry. To provide a compatible two-wire input, some type of conversion bridge network is required.

PRESSURE TRANSDUCERS

A notable achievement of the past year has been the design of low-cost pressure transducers. In order to log pressures, a large number of transducers that are capable of converting pressure to an analog electrical signal must be incorporated in a logging system.

For purposes of brevity this paper limits the discussion to a typical transducer suitable for operation from a 3 to 15 lb./sq.in. pressure input. Most units on the market utilize the differential transformer, variable reluctance, or resistance, to achieve pressure to electrical conversion.

The transducer illustrated in Figure 6 converts the 3 to 15 lb./sq.in. input pressure to a direct current output voltage.

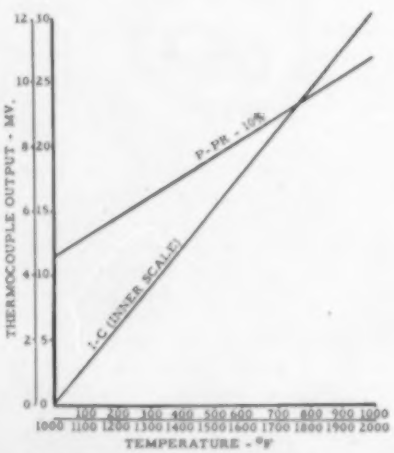


Fig. 4. Thermocouple millivolt output curves.

The deflection of the bellows moves the wiper of the multiturn potentiometer through a linkage mechanism. Thus, it can be readily observed that the calibrated output voltage is a direct function of input pressure. Amplification of the bellows motion is achieved by means of the fulcrum illustrated in Figure 6. Output amplification is B/A.

The bellows-type transducer will operate well only at low-pressure ranges; consequently, for higher pressures it is necessary to use Bourdon tubes or strain gauges.

FLOW TRANSDUCERS

A flow transducer must effectively convert the pneumatic flow signal, which is proportional to head meter differential, to an electric output signal. The pressure transducer described in the preceding paragraph and the flow transducer differ only in that the latter must incorporate some provision for square-root extraction.

Square-root extraction may be simply accomplished by use of two linear ganged slide-wires or by means of shunt resistors used in conjunction with a tapped potentiometer. The shunt method provides a straight-line approximation. This method will be discussed at some length under the integration section of this paper.

In order to present an analysis of square-root extraction, some understanding of the basic fundamentals of potentiometer multiplication will be helpful. Potentiometers are simple, dependable, reliable, and inexpensive devices capable of considerable precision.

The basic multiplication circuit is shown in Figure 7 (*5*). Here two potentiometers are shown cascaded to perform the multiplication function. A constant voltage E is supplied to one end of the first potentiometer. The shaft rotation representing the first variable sets off a proportionate resistance R_1 on the first potentiometer, which has a total resistance R_{t1}. The shaft rotation representing the second variable sets off a correspondingly proportionate resistance R_2 on the second potentiometer, of total resistance R_{t2}. The voltage at the brush of the first potentiometer is $E(R_1/R_{t1})$, while the voltage at the brush of the second potentiometer is $E(R_1/R_{t1})(R_2/R_{t2})$. The product R_1R_2 is thus obtained.

In the analysis no mention is made regarding the loading effect of the second potentiometer. It is necessary that the second potentiometer have a large resistance compared with the first potentiometer. The loading effects produced by ganged potentiometers may be avoided by means of isolating stages between them. A cathode-follower amplifier, designed with a high input resistance and a low out-put resistance, may be used for isolation.

Figure 8 illustrates a typical square-root circuit obtained by cascading a pair of ganged potentiometers.

The voltage e_1, representing the input voltage from a flow transducer, is impressed across one side of the servoamplifier. A servomotor M drives a ganged linear potentiometer assembly R_1R_2. The ganging causes both potentiometer wipers to be at the same fractional position of their total travel. An essential design requisite for this circuit is the reason why i should be derived from a constant current source. Therefore, it follows that

$$i = \frac{E}{K} = \text{constant}$$

where E is the reference voltage obtained from the constant current source. The output voltage e_2 is

$$i_2(R_2)x$$

where x represents the fractional position of total potentiometer travel. Current i_2 may be given by the expression

$$\left(\frac{E}{K}\right)\frac{(R_1)(x)}{R_1+R_2}$$

wherein the output voltage e_2 will equal

$$\left(\frac{E}{K}\right)\frac{(R_1)(x)}{R_1+R_2}(R_2)(x)$$

where the quantity containing K, R_1 and R_2 may be grouped and represented as K^1 a circuit constant. Therefore, the output voltage e_2 may be expressed as

$$\frac{E}{K^1}x^2$$

Hence voltage e_2 is a function of the fractional displacement of the ganged potentiometers.

The voltage e_2 is impressed across the servoamplifier terminals as shown in Figure 8. Any difference between voltages e_2 and e_1 is amplified and then used to operate the servomotor M in a direction to reduce the difference voltage to zero. The shaft position of the servo is therefore a measure of the square root of the input from the flow transducer.

INTEGRATION

Fundamentally, integration is a process of accumulation. Any device capable of receiving and storing physical quantities and indicating the quantity stored may be used as an integrator (*6*). In an automatic logging system provision for averaging flows and other quantities over a period of time is necessary. It is important to note at this time that some type of time compensation is required

New Techniques in PROCESS CONTROL

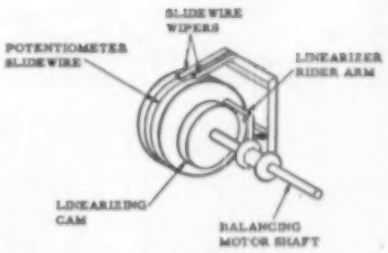


Fig. 5. Linearizing system.

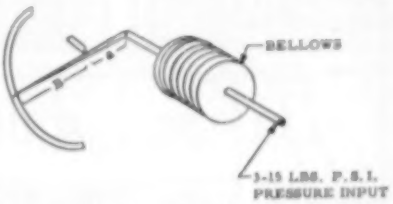
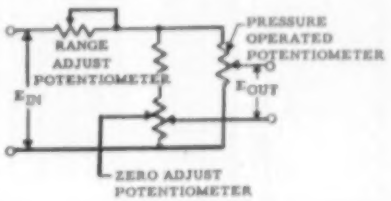


Fig. 6. Above, functional diagram, and below, schematic diagram of pressure transducer.



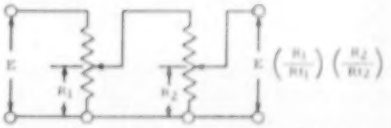


Fig. 7. Basic multiplication circuit.

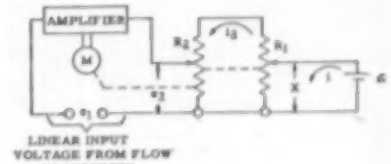


Fig. 8. Typical square-root circuit obtained by cascading a pair of ganged potentiometers.

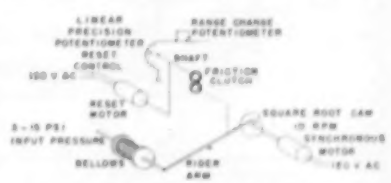
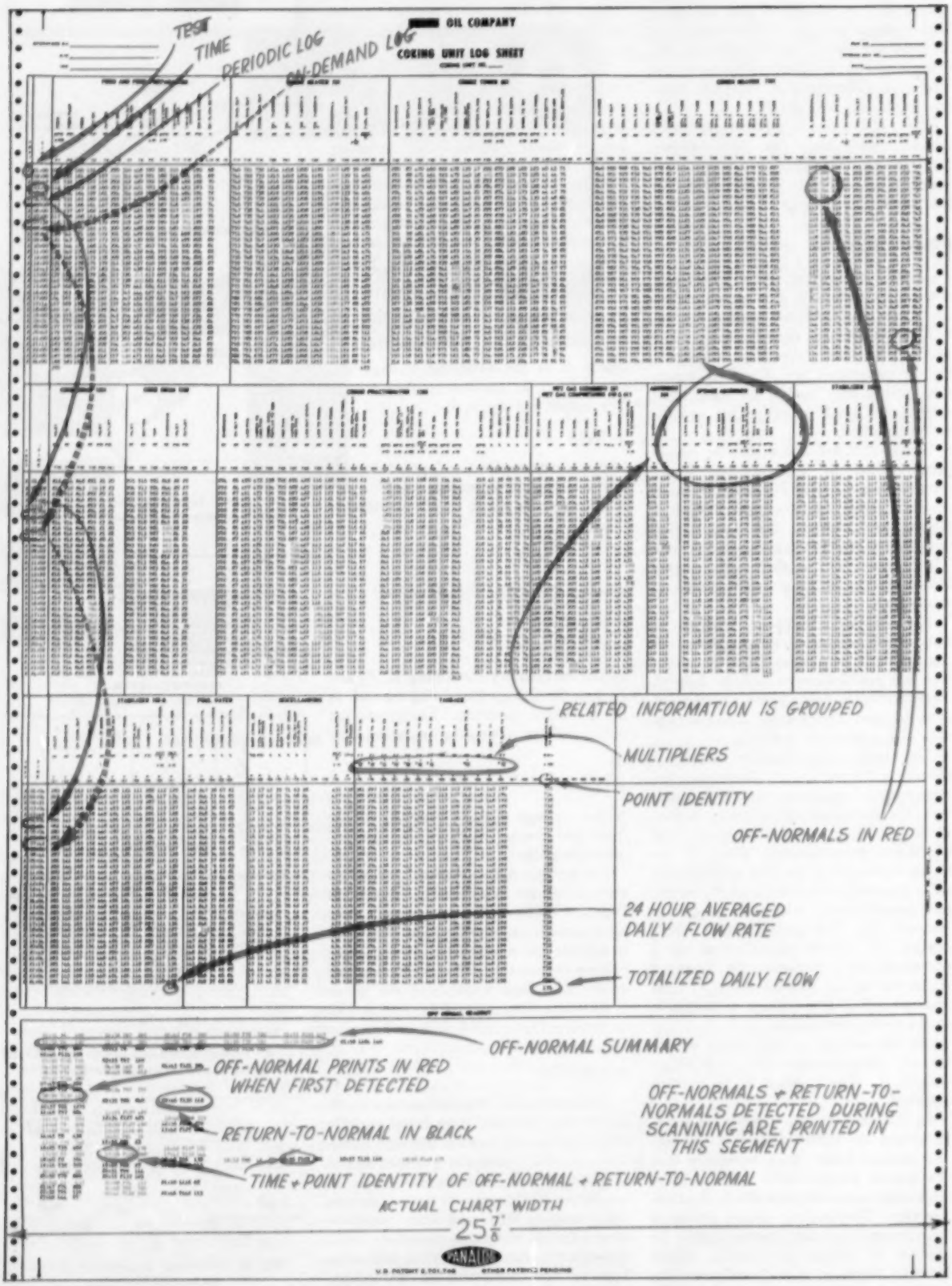


Fig. 9. Functional diagram of electromechanical integrator.

Panalog Information System Log Chart



where "on demand" logging of averaged variables is incorporated in the logging system.

Although integration may be performed electronically by means of charging current into a capacitor or mechanically by means of the ball and disc, this paper restricts itself to the description of a specific type of electromechanical integrator. A complete analysis will be made also of the time compensation function for "on demand" logging.

Operation of an electromechanical integrator is illustrated in Figure 9. The integrator converts a retransmitted differential pressure to an electric signal proportional to average hourly flow. The pneumatic line is connected directly to a bellows which expands and contracts proportionally with the variations in pressure. Bellows position is transmitted through a mechanical linkage to position a pointer arm which controls the engagement of a clutch. This clutch is controlled also by a square-root cam, such that the engaged time of the clutch is proportional to a square-root function of the pointer-arm position—that is proportional to instantaneous flow. The cam rotates at 10 rev./min. so that 600 samples of flow are taken each hour. The accumulated motion transmitted by the clutch is thus proportional to average hourly flow. The output motion of the clutch is transmitted through a gear train to a precision potentiometer which in turn provides an electric output proportional to flow. Range or scale factor of the potentiometer is adjusted by means of a variable resistor in series with the potentiometer slidewire.

At the end of the integration period an electric impulse from the logging-system programming unit causes a reset motor to drive the potentiometer back to zero so that a new sample may be taken for the next time period.

On pressure-compensated units the pointer-arm position determined by the bellows is modified by a second bellows through a mechanical multiplying linkage. In this unit the pointer-arm position represents the differential pressure corrected by the absolute pressure of the flow line. The rest of the operation is the same as on the standard unit.

Where necessary a second output potentiometer is added to the end of the gear train for 24-hr. accumulation. This unit also has an independent reset.

If the flow is read out at regular time periods, no further correction is required. However, if the flow is read out at some time before this regular time, some type of time compensation is required.

To describe one method of compensation, reference is made to Figure 10. A synchronous motor is geared to a time-compensating potentiometer, which varies the input voltage to the integrators in the system. The first assumption is that the output from the integrator corresponds to 100% flow and that a periodic log is taken at 1-hr. intervals. If the nominal output from the integrator is 25 mv. at full flow, the output at 1 hr. is 25 mv. However, if an "on demand" log is initiated at 30 min., only one-half the output voltage would appear at the integrator terminals. It is necessary, therefore, to provide time compensation in the system.

Complete account must be taken of the loading effect of the various integrator impedances when designing the time correction potentiometer. It will be assumed that it is not feasible to utilize a stable-isolating amplifier due to the low direct-current voltage output required from the integrator. Zero stability may be obtained from an amplifier however if the direct current is converted to alternating current through a mechanical chopper, amplified through an alternating-current amplifier, and then rectified.

The averaging potentiometers in the integrator are reset immediately after the periodic log. Since it is not possible to accumulate a statistical average of any reasonable accuracy immediately after reset, average values are blocked from being printed on "on demand" logs for approximately 5 min. after being reset.

The Dual Functions

Since the dual function logging system incorporates supervision of process variables on a continuous scanning basis as well as providing an automatic log of all variables, it, therefore, would be desirable to discuss each of the dual functions separately.

SCANNING

During the scanning cycle of the program the system sequentially compares each electric signal representative of a process variable with that variable's own high and low limits. Simultaneously, it checks a memory unit relevant to the same variable to determine (1) whether the variable is currently normal or abnormal, and (2) whether the variable memory indicates the variable was normal or abnormal.

In the event that a change of state as indicated by either a new alarm or a new normal condition of that variable is found, the variable will be quantized and a digital record will be made. Reference to the off-normal readout section of the chart illustrated in Figure 3 is representative of such a printout. The digital record includes the time, point identification, and magnitude of the variable. Differentiation between a new alarm and a return to normal condition is accomplished by printing the magnitude in red if the variable is abnormal and in black if it is normal.

High-speed switching, and low-signal levels, make gold contacts on all switching devices essential. Signal leads should be a twisted pair, and should be shielded to eliminate induced voltages from adjacent equipment.

Pneumatic switching may be utilized to actuate sequentially solenoid valves. This type of switching is not readily compatible in a logging system where temperature and flow measurements are required. Caution must be exercised to allow adequate time for pressure stabilization. Low-speed switching is a consequence of pneumatic scanning.

Alarm Detection

An electronic deviation detector is generally used for alarm detection. Abnormalities are detected by comparing amplified input voltages with alarm limit reference voltages, and by noting the change in polarity when variables go beyond limits. No attempt is made to quantize in the detector.

Two basic methods of alarm detection may be used in an automatic logging system. The first utilizes a retransmitting slide-wire within the null-balance potentiometer. This circuit is illustrated in Figure 11. At least one alarm set-point potentiometer is provided for each point. Where high and low detection is required, two retransmitting slide-wires and two set potentiometers are required. Each set-point potentiometer is switched into the comparator circuit where the retransmitting slide-wire voltage is compared to the individual set-point voltage. The circuit may be designed such that a positive voltage difference will trigger a thyratron. Automatic printout of that particular point then will occur. The two main disadvantages inherent in a system of this type are that slow-speed scanning results due to the necessary balance time

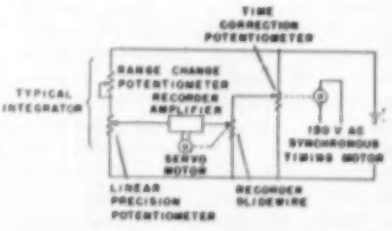


Fig. 10. Time compensation correction circuit.

◄ Fig. 3.

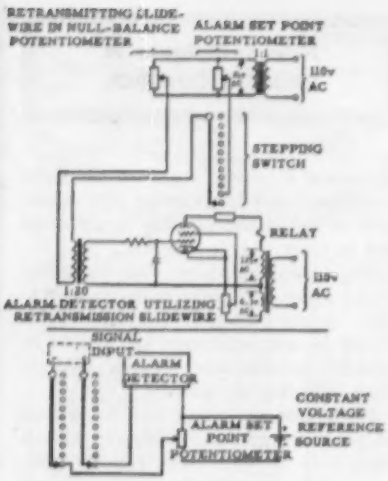


Fig. 11. Alarm detector using electronic comparator.

of the null-balance potentiometer, plus the fact that excessive wear of the slide-wires will result in a severe maintenance problem.

Electronic alarm detection involves no moving parts since the variable input signals are connected directly to the detector. High-speed scanning is also possible since the speed is limited only by the time at which the variable itself can be switched. The basic electronic circuit is illustrated in Figure 11. In order to detect alarms within 1° F. (iron-constantan), it is necessary that the detector sense a deviation of 25 μv. from the alarm set voltage. The direct-current difference voltage is fed first into a vibrating reed converter which chops up the voltage into an alternating-current signal. This voltage is then amplified, after which it triggers a thyratron if it is of proper value. It is essential that spurious electrical noise be prevented from interfering with the alarm detector operation. An amplifier of the type described operates at low levels and has a high gain, thereby making it quite susceptible to induced alternating-current or direct-current fields.

Alarm Memory

Individual alarm-memory elements provide the feature of alarm printing only when a variable goes off normal and, again, when the variable returns to normal. Without point-alarm memory, an abnormal variable would be reprinted once each scan cycle until restored to normal. This would be valueless recording and would result in rapid fill-in of chart area making it necessary to use a plurality of log sheets for each 24-hr. period.

An alarm-memory unit has two stable states which are reversible by the application of appropriate signals. A prime requisite of this element is that memory is not lost by a power failure. A latch relay meets all the requirements specified previously. Another device available commercially is the hysteresis relay, which also has two stable states. Energization of the coil with a positive pulse polarizes and seals in the relay. It remains in the "sealed in" state until a reverse polarity pulse is applied to the coil. The same principle is used in the double-coil relay.

LOGGING

Tabulation

The manner in which information is presented to the operator is of utmost importance. For practical and useful plant operation a complete record of all vital variables should be logged automatically at regular intervals. Furthermore, a complete log must be made available "on demand" when required by operating personnel.

A novel multisegment patented log sheet is illustrated (Fig. 3). The typewriter platen drives bidirectionally which, under control of the chart programmer, presents the proper segment to the keys. The automatic typewriter is so controlled that it records periodically the scanned values of all process variables in the longitudinally spaced, segmental areas. Data on seventy-two 3 digit variables can be recorded in each segment of the chart. Four segments with preprinted headings can be easily accommodated on one log sheet, plus space for off-normal recordings. The log sheet is preprinted with point numbers and measurement units at the top of each segment. Numerical data on the corresponding process variables are aligned in vertical rows in each segment under the corresponding process variable.

At the beginning of each log cycle the system automatically goes into a test and standardization procedure which sequentially standardizes all battery electromotive force sources, checks the performance of the alarm detector, and also checks the calibration accuracy of the null-balance digital measurement system. If all of these checks are satisfactory, the typewriter prints an x in the test column of the chart. If any fault is found during this test procedure, a system fault light on the control panel is energized and the alarm bell is sounded to call the operator's attention to the fact that the system is defective.

After the test signal is printed, the time base represented in hours and minutes is typed automatically at the beginning of each line. Following the printing of a line in the first segment of the chart, the typewriter indexes to the second segment where printing of the second group of variables occurs. This action is repeated until a line has been printed in the last segment. At this time line-spacing control automatically positions the chart to receive printing in the "off-normal" section of the chart.

If the operator requires further information regarding process trends, he may initiate an "on-demand" readout at any time. A complete log is then printed one line below the preceding periodic readout.

Space is provided at the bottom of each segment for 24-hr. "averages" and "totals" printout. Optionally a separate section could be provided. This could best be described as the accounting section since the total throughout for the day may be automatically tabulated for use by the accounting department.

Measurement System—Analogue Digital Converter

The two types of measurement systems in general use are the null-balance potentiometer and the frequency counter. In a null-balance potentiometer the input voltage is measured against a known slide-wire voltage. Any difference between the two voltages is amplified. The amplified output voltage energizes a two-phase balancing motor which moves the "measuring" slide-wire until the difference voltage is equal to zero. The slow speed inherent in this type of measurement allows full advantage to be taken of the basic precision of the measuring slide-wire.

Reference-junction resistors automatically compensate for variations in thermocouple reference-junction temperature. Standardization of the instrument is provided automatically by means of the test cycle initiated prior to each log.

A null-balance potentiometer provides a mechanical output in the form of a shaft movement, the angular position of which is a magnitude of the input signal voltage. The shaft position is therefore a measure of the value of the process variable which is coupled to it by the switching system. If the input voltage is nonlinear, suitable linearizing cams or potentiometers are required as discussed previously. The master programmer within the logging system must then select the proper slide-wire and bridge circuit for each variable. The output shaft of the potentiometer is coupled to a digital converter which converts the single shaft output to three (or four) separate shaft positions. These positions represent respectively the three digits of a number which represent the angular position of the shaft which in turn represents the value of the variable

(*1*). This type of converter is electromechanical in operation.

Converters of this type usually include three or four 10-position switches, the wiper contacts of which connect with contacts 0-9, which represent the digits of a three-digit number. Figure 12 illustrates a typical code matrix which converts the decimal output of the converter to a five-channel code suitable for operation of an electric typewriter. The output of the converter can be in the form of a binary code or any other code of similar nature. In each case, however, the same design problem exists—namely, translation of the converter output to a code suitable for printer operation.

Figure 12 also illustrates the conversion of the analog-digital converter output to a five-channel printer input by means of a diode matrix. The system print programmer sequentially scans the hundreds, tens, and units wipers of the analog-digital converter. If the wiper of the "hundreds" switch is in the zero position, channels two, three, and five of the typewriter are energized. The translating magnets within the typewriter are so arranged that energization of channels two, three, and five provide a zero print.

A major problem that presents itself in the design of any analogue to digital converter is the elimination of ambiguity. It is possible for the wiper to be positioned so that it bridges two digits, thus causing a false code to be fed into the printer. It is possible to eliminate ambiguity electrically by means of special code plates or mechanically by positioning the brush within the center of each plate. No attempt will be made to elaborate on the many methods used to eliminate ambiguous readout.

A second type of measurement system in common use uses a time-varying reference which converts a voltage level to a time difference and then measures the time, which is proportional to voltage (*3*). A sampling of the signal voltage is obtained in the following manner:

At the signal from a clock a counter begins to count pulses from a constant frequency oscillator, and a sawtooth generator then generates an output voltage with a linear time-voltage characteristic. A null detector is used to detect the time at which the sawtooth voltage is equal to the signal voltage. When the null detector is triggered, the counter stops and is read out. The count is proportional to the signal voltage.

The main benefit derived from this type of system is speed, since 50 to 1,000 points/sec. can be sampled. It is quite difficult to sample the small voltages generated by thermocouples and thus its usage is limited somewhat. The problem of linearizing thermocouple curves and square-root functions further inhibits the use of the time-varying measurement system in an automatic logging system.

Programming

The operating heart of the automatic logging system is the programmer. It is this component that directs and controls the flow of data through the system.

For purposes of discussion, the programming functions may be categorized in the following groups: (a) chart; (b) test; and (c) print.

The chart programmer, or log positioner is an electromechanical motor-driven programmer which provides positive vertical positioning of the log chart. Through its action the log chart is always rotated to the correct position for cyclic, demand or off-normal printout.

A gear train couples the typewriter platen to the chart programmer. Printed circuit commutators, driven by the gear train, provide mechanical memory of line spacing between segments and of the number of lines printed in a segment. Electric signals for rotating the platen is fed to the drive motor through the commutators providing a positive address for each line in the log.

The test programmer consists of a rotary stepping switch which checks standardization of the various e.m.f.'s and calibration of components used with the system. A complete test program is initiated prior to each log printout.

The print programmer also consists of a rotary stepping switch. Function of the print programmer is to read out sequentially the variable magnitude from the analog-digital converter storage. It also directs action of the carriage return, time printout, space, color shifts, and other typewriter functions.

Conclusions

The future of automatic logging of industrial processes is very bright. A back-up system of recording and graphic instrumentation will be used until sufficient confidence is placed in the logging system. Control of process variables will probably be guided by deviation instruments and trend recorders.

New Techniques in PROCESS CONTROL

An initial problem will be the education of maintenance personnel. Downtime could be a serious problem once back-up instrumentation is eliminated. However, it may be assumed that reliable long life components will be used or developed as the field develops. Self-checking features within the logger are of prime importance. A "trouble shooting" maintenance panel should be included as a basic part of each system. Great advances will be made in miniaturization. Amortization of logging equipment will be accelerated by improved techniques in manufacture.

Initially punch card output will provide the accounting department with daily output and other statistical data. Ultimately the output from the logging system will be fed directly into a computer from which feedback will be initiated.

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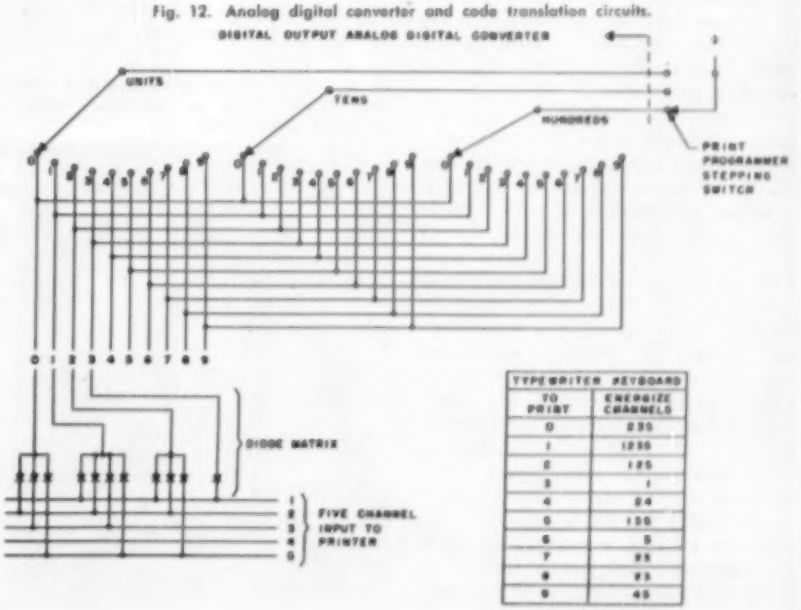
Fig. 12. Analog digital converter and code translation circuits.



TYPEWRITER KEYBOARD	
TO PRINT	ENERGIZE CHANNELS
0	235
1	1235
2	125
3	1
4	24
5	124
6	5
7	25
8	25
9	45

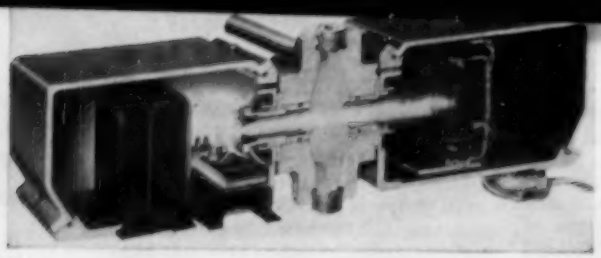


Fig. 1. Cut-away view of flow colorimeter.

New applications of devices for AUTOMATIC CONTROL

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The trend in virtually every industry is from batch to continuous processing. Consequently, analytical instrumentation has become extremely important. Until a few years ago almost all process-control operations depended upon rather simple devices that would sense level, flow, temperature, and pressure. These devices performed, and will continue to perform, necessary functions in all automatic control systems; however, they are limited in the job that they can do from an analytical standpoint. For the most part, they control processes by sensing a secondary value. In use in laboratories, however, are many reliable methods that measure primary variables, that is, the quantitative presence or absence of the material of interest in a sample. The techniques used at present include ultraviolet, visible, infrared, and mass spectroscopy; flame photometry; gas- and liquid-phase chromatography; countercurrent extraction; continuous titration; and many other specific methods. With these techniques it is possible to determine the composition of a sample fairly quickly, very accurately, but unfortunately rather expensively if due consideration is given to the cost not only of operating a 24-hour laboratory but of blending off quality material produced between sampling periods.

Actually, the instrument manufacturers, strongly aided by progressive chemical and petroleum companies, have caught up with many of the industrial demands. Instruments are now available that require only the application of process engineering knowledge to allow them to be put into successful stream operation. The trend is definitely toward moving a laboratory into the process stream. The economic advantages are great and lie in improved quality, higher throughput, elimination of holding and blending facilities, lower operating cost, and longer equipment life.

Instrumentation, like direct labor, requires discriminating use. Careful consideration should be given to the functions of each instrument that is to be installed. Instruments today are generally reliable, but even the most carefully designed unit is certain to malfunction sometime during its life unless adequate preventive maintenance schedules are observed.

Stream-analysis Instruments

Good instrument engineering dictates the use of an instrument at every point where it is needed, but only where it is needed. Quite a large number of stream-analysis instruments are already in service. Some of the applications to which they are being put are discussed here to stimulate the imagination of the process engineer.

FLOW COLORIMETER

One of the simplest instruments of the stream-analysis type is the flow colorimeter. Figure 1 shows a cut-away view of this instrument, which measures the amount of light of a specific color that is transmitted by the sample stream. If the active ingredient of a stream is colored, the color intensity at a certain wave length is a function of the amount of the substance in a stream. Hence, if the instrument is sensitized to that wave length by means of the proper filter and the energy characteristics of the source and the characteristics of the phototube detector are taken into account, then the instrument response is a measure of the amount of that particular substance in the stream. This is a relatively simple application.

Less obvious applications involve the measurement of colorless constituents. In this case, by means of an addition system, a small quantity of reagent is added continuously to a portion of the stream before it enters the flow colorimeter. This reagent is chosen to develop a specific color with the constituent of interest. The intensity of this color becomes proportional to the concentration of the desired constituent. Figures 2 and 3 illustrate some practical applications of these techniques.

Fig. 4. Flow colorimeter being used with a reagent-addition system to determine residual chlorine in potable water.

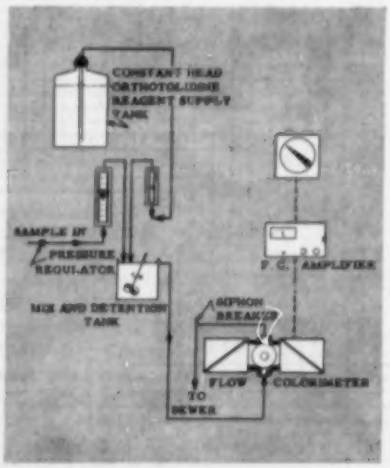

Figure 2 shows a flow diagram of a wax-decolorizing process. Here the molten colored wax is treated with clay in an agitated vessel. This is a continuous operation. The clay, after decolorizing the wax by adsorption, is filtered from the stream and the wax is sent to storage. If too much clay is added, the process will not operate economically, for not only will the clay costs be high, but the filter will have to be discharged often. Of course, if insufficient clay is added, the resultant wax will not meet specifications. A steam-jacketed flow colorimeter is used in this particular operation to monitor the filtered wax. At present the control is manual in that an operator controls the rate of clay added by the automatic feeder, but it is anticipated that this final step also will soon be automatic and the control loop will be completed.

Figure 3 shows the utilization of a flow colorimeter in monitoring the exhaust gas from a hydrocarbon chlorination reaction. The instrument, which is sensitized to chlorine, sets off an alarm whenever it senses an overconcentration of chlorine. Here again it is a very easy step to close the loop by operating a chlorine-control valve from the recorder controller.

Figure 4 shows the flow colorimeter being used with a reagent-addition system for the determination of residual chlorine in potable water. The concentration of chlorine here is about 0.5 p.p.m. The chlorine at this concentration is, of course, not colored; consequently, orthotolidine reagent is added continuously to achieve a yellow color, which is monitored.

When it is realized that there are more than 2,000 color reactions, the potentialities of this technique are im-

pressive from a stream-control point of view.

The flow colorimeter can also be used in an entirely different manner, for instance, to determine continuously the clarity of a colored or colorless sample. In the solution of a filtration or clarity problem, the same principle holds as in colorimetry; that is, the suspended particles scatter the light, thus preventing some of it from reaching the phototube. The amount of turbidity is then an inverse function of the amount of light reaching the detector.

Figure 5 illustrates the use of this instrument as a turbidimeter in a paper-making operation. The unit labeled "Saveall" in this particular case can be regarded as a continuous filter. If the solids content of the effluent exceeds a preset limit, then an alarm is sounded and the operating conditions of the Saveall are changed to bring the effluent within range. The same application would hold true on any type of continuous filter or continuous settling operation.

Figure 6 illustrates the use of two of the instruments in a rather peculiar manner, that is, on both sides of a plate and frame filter. The purpose of the colorimeter on the input side is to enable the filter to be operated with the most economical duty cycle, and of course the unit on the effluent side is to monitor the clarity of finished beer.

Many considerations have to be taken into account in engineering an instrument into a complete control loop. In

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the author's work on *p*H and flow colorimetry an analog plant has been designed wherein the complete system response can be checked to anticipate upsets in process operations. Figure 7 shows the control panel of this plant and Figure 8 shows the flow diagram of the operation. In this analog the customer's sample or a synthetic sample made up to approximate the plant sample may be fed through a rotameter into any type of mixer, e.g., pipe line,

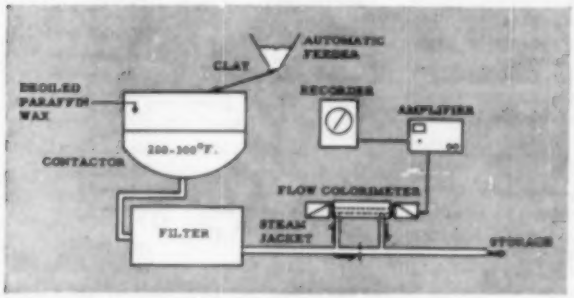

Fig. 2. Continuous monitoring of Saybolt color.

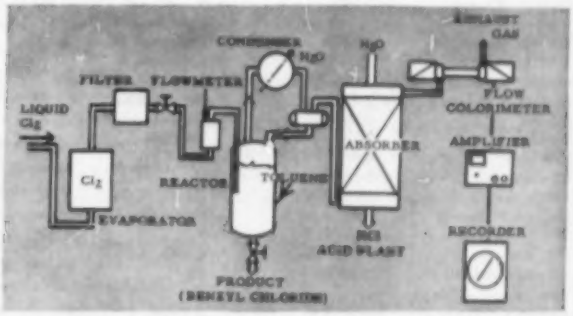

Fig 3. Continuous chlorine measurement in exhaust gas.

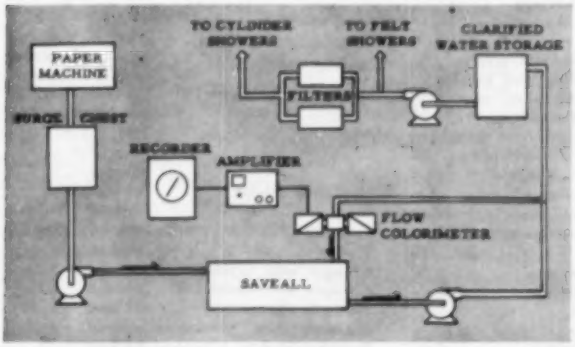

Fig. 5. Monitoring solids in "saveall" effluent.

Fig. 6. Continuous determination—turbidity in beer.

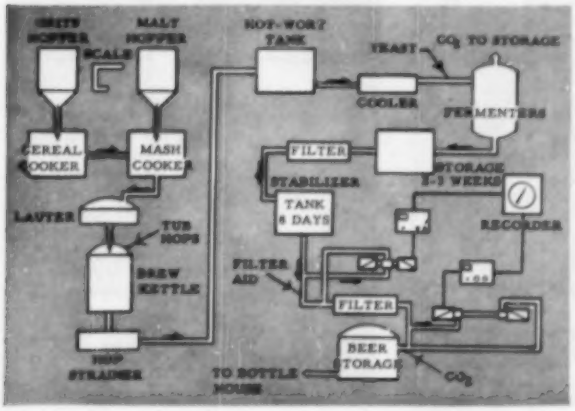

Fig. 8. Flow diagram of analog plant.

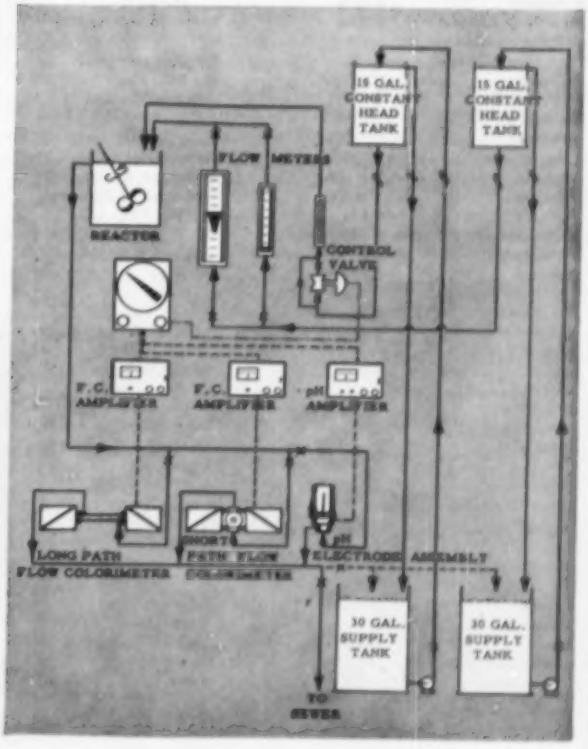

Table 1.—Typical Applications of Analytical Instruments

Component	Concentration	Other major constituents	Type of plant	Service	Instrument
Acetylene	0.8 p.p.m.	Oxygen	Air separation	Liquid air vaporizer	Infrared
Acetylene	0-20%	Methane, ethylene	Acetylene	Partial oxidation	Infrared
Acetylene	0.3%	Carbon dioxide	Acetylene	Absorber off gas	Infrared
Acetylene	500 p.p.m.	Ethylene	Ethylene	Product	Infrared
Acetylene	0-10%	Butadiene, butene-2	Butadiene	Butadiene purification	Infrared
Alcohol	Range	Water	Alcohol	Distillation	Refractometer
Ammonia	10.8%	Air	Nitric acid	Reaction cases	Infrared
Ammonia	50%	Carbon dioxide	Urea	Recycle gas	Infrared
Butadiene	0-10%	Butanes & butylenes	Butadiene	Purification	Ultraviolet
Butene-2	0-70%	*n*-Butane	Butadiene	Furfural extractive distillation	Infrared
Butene-1 & isobutylene	0-40%	Butadiene, butene-2	Butadiene	Furfural extractive distillation	Infrared
Carbon dioxide	5 p.p.m.	Air	Air separation	Treated air	Infrared
Carbon dioxide	0.5%	Acetylene	Acetylene	Acetylene product	Infrared
Carbon dioxide	15%	Ammonia	Urea	Recycle gas	Infrared
Carbon dioxide	0-20%	N_2, O_2, H_2O	Butadiene	Catalyst regeneration	Infrared
Carbon dioxide	0-1%	N_2, H_2, CO	NH_3	Synthesis plant	Infrared
Carbon monoxide	500 p.p.m.	Light hydrocarbons	Public utility	Fuel gas	Infrared
Carbon monoxide	8-10%	Carbon dioxide air	Fluid cat. cracker	Regeneration flue gas	Infrared
Cyclohexane	60%	*n*-Hexane	Petrochemical	Distillation column	Refractometer
Cyclohexane	0-5%	Methyl cyclopentane	Cyclohexane recovery	Dimethylcyclopentanizer	Refractometer
Divinyl acetylene	0.5 p.p.m.	Acrylonitrile	Acrylonitrile	Product	Ultraviolet
Ethane	40-60%	Ethylene	Ethyl chloride	Feed	Infrared
Ethane	0.1%	Ethylene	Ethylene	Product	Infrared
Ethylene	0-5%	C_1—C_5	HF alkylation		Infrared
Ethylene	0-20%	H_2, C_1—C_4	HF alkylation		Infrared
Ethylene	50-100%	C_2, C_3, CO_2	Polyethylene		Infrared
Carbon monoxide	10 p.p.m.	Hydrogen & nitrogen	Ammonia	Nitrogen wash tower OH & synthesis gas	Infrared
Ethylene	75-100%	C_2, C_3, CO_2	Polyethylene		Infrared
Ethylene oxide	0-50%	C_2, C_3, C_5	Natural gas to ethylene oxide		Mass spectroscopy
Helium	+99.9%	Oxygen & nitrogen	Gas separation	Product	Thermal conductivity
n-Heptane	0-5%	Isoheptane	Natural gasoline fractionation	Deisoheptanizer	Refractometer
Hydrocarbons	3 p.p.m.	Oxygen	Air separation	Air comp. inlet	Infrared
Hydrocarbons	5%	Helium & hydrogen			Infrared
Hydrocarbon	0-10%	H_2S, CO_2	Sulfur recovery		Mass spectroscopy
Hydrocarbon	0-1%	Air	Drilling mud logging		Mass spectroscopy
n-Hexane	0-10%	C_5 and C_7	Cyclohexane recovery	Denormal hexanizer	Refractometer
Hydrogen sulfide/ sulfur dioxide	0-10%	Water, CO_2, N_2	Sulfur recovery		Mass spectroscopy
Hydrogen sulfide	0-2%	Propane-propylene	L.P.G. purification		Ultraviolet
Isobutane	0-100%	C_3, *n*-C_4, *i*-C_5	HF alkylation		Infrared
Isobutane	10%	*n*-Butane (liquid)	Alkylation	Distillation column	Refractometer
Isobutane	0-30%	*n*-C_4	Deisobutanizing fractionator		Infrared
Isobutane	0-100%	C_3, *n*-C_4, *i*-C_5	Isomerization		Infrared
Lube oil (gas)	2,000 p.p.m.	Helium			Infrared
Methane	5 p.p.m.	Hydrogen & nitrogen	Ammonia	Nitrogen wash tower OH	Infrared
Methane	1 p.p.m.	Hydrogen & nitrogen	Ammonia	Nitrogen wash tower OH	Infrared
Methane	0-5%	H_2, N_2, CO_2, CO	NH_3	Synthesis plant	Infrared
Methane	0-15%	N_2, H_2, A, He	NH_3	Synthesis plant	Infrared
Methane		Ethylene & acetylene	Acetylene	Partial oxidation	Infrared
Methane	0.1%	Ethylene	Ethylene	Product	Infrared
Methane & ethane	8%	Ethylene	Ethylene	Product	Infrared
Methanol	500 p.p.m.	Air			Infrared
Isobutane	0.5-10%	*n*-Butane & isopentane	Alkylation	Deisobutadiene bottoms & debutanizer OH	Infrared
Methyl ethyl pyridine	0-5%	Methylvinyl pyridine	Steam fractionation	(MEP-MVP)	Refractometer
3-Methyl pentane	0-5%	C_6	Natural gasoline fractionation	(Denormalpentanizer)	Refractometer
NO—NO_2	0.2%	Stack gases	Nitric acid	Stack gas	Infrared
Nitric acid	Range	Water	Nitrates	Nitric acid feed	Refractometer
Nitrogen	0-10 p.p.m.	Argon	Argon		Mass spectroscopy
Olefins (total)	0-100%	C_3-C_4 Hydrocarbon	HF Alkylation		Infrared
Ortho- & metaxylene	0-3%	paraxylene	High-purity paraxylene process		Refractometer
Oxygen	0-10 p.p.m.	Ethylene	Polyethylene		Mass spectroscopy
Oxygen	0-10 p.p.m.	Argon	Argon		Mass spectroscopy
O_2, N_2, CO, H_2O	0-5%	H_2	Vacuum metal refining		Mass spectroscopy
Styrene	Range	Ethyl benzene			Refractometer
Sulfur dioxide	2%	Stack gases	Sulfuric acid	Stack gas	Infrared
Water	50 p.p.m.	Air	Air separation	Treated air	Infrared
Water (liquid)	0-0.3% by wt.	Liquid SO_2	Aromatic extraction		Infrared
Xylene isomers	0-5%	Isomers	Paraxylene	Product	Refractometer

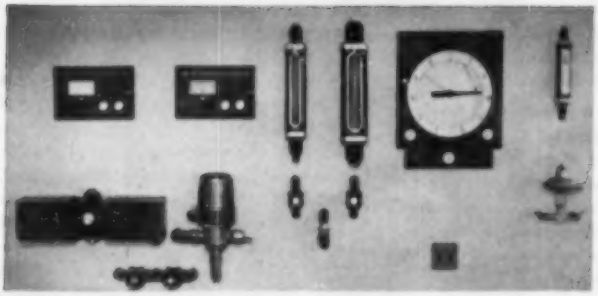

Fig. 7. Control panel of analog plant in which it is possible to check complete system response to anticipate upsets in operations.

New Techniques in PROCESS CONTROL

agitated weir. The reagent, or treating, solution is then added through a rotameter and flow-control valve to the mixer. After the reaction takes place and the proper amount of dead time and transport lags are added to approximate the customer's plant conditions, the reacted effluent is fed to either a flow colorimeter or a pH sensing device. The electrical signal from these is then fed to a recorder controller, and a pneumatic signal back to the control valve completes the loop. In this manner the proportional and reset values that have been previously calculated for the system by the method of Kehoe, Silva, and Noebels (*1*) can be checked.

INFRARED REGION

A little further into the spectrum is the infrared region, which has tremendous potentialities for stream control. There are a number of instruments for use in this area on the market at present. These instruments are of two general types, nondispersive and dispersive. The nondispersive type is used in gaseous problems, and the dispersive unit is used primarily for liquid streams. This is a general rule, to which there are some notable exceptions. Actually, the principle on which these units operate is identical to that of the flow colorimeter. The amount of absorption of radiant energy of a specific wave length is a function of the concentration of the desired component in the stream.

Figure 9 shows the interior construction of a Liston-Becker model 21 nondispersive unit. The solenoid valves on the left side of the unit are for standardization through either manual operation or an automatic switch. Figure 10 shows the inner workings of the dispersive unit. The use of a prism in this unit allows for great versatility; therefore this particular type of instrument is well suited for pilot plant operation where the analysis of several different components in separate streams might be required, each however for only limited length of time. The present and potential uses of these units are great. One important potential application of the dispersive unit is in the control of the feed and overhead and bottom take-off of continuous fractionation columns. This is an application that can be counted upon to increase greatly in the next few years.

Table 1 lists many of the instruments now being used for process monitoring or control. It will be noted that the portion of this table dealing with the infrared region is quite large.

MASS SPECTROSCOPY

Another area of increasing importance is the use of mass spectroscopy for plant-stream analysis. Figure 11 shows a commercial mass spectrometer that is capable of monitoring a stream for six components. Infrared, vapor-phase chromatography, and mass spectroscopy overlap to some degree in their applications to stream-analysis work. There are certain instances, however, where the mass method is the only practical method of analyzing for certain substances, for instance, the measurement of argon and nitrogen in ammonia plants. Here the abridged mass unit can do yeoman's duty.

Another interesting application of this unit is in mud logging. In oil drilling, a substance called *mud* is used to lubricate the drill bit, to wash away cuttings, and to provide a hydrostatic head. This mud is continuously circulated. In mud logging, the entrained gas in the mud is continuously analyzed as it comes from the well to determine the kinds and amounts of volatile hydrocarbons present, so that the operators may ascertain when the drill bit is in an oil-bearing formation.

VAPOR-PHASE CHROMATOGRAPHY

There is one up-and-coming technique that has tremendous potential value and bears very careful watching by the process engineers. This is the technique of vapor-phase chromatography. In effect, this operation is very familiar to chemical engineers. A small sample, either liquid or gas, is introduced into a stream of inert carrier gas such as helium and is passed through a packed column that is impregnated with a high-boiling organic liquid. The column, in effect, fractionates the sample into its components by gas-liquid partition at the liquid interface which is immobilized by absorption on the carrier. A detector

Fig. 9. Interior construction of Liston-Becker model 21 nondispersive infrared unit.

Fig. 10. Interior view of a dispersive infrared unit.

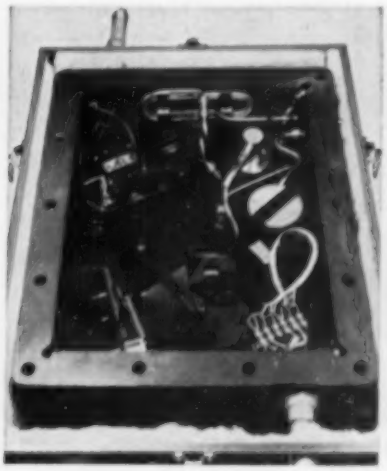

Fig. 11. This console mass spectrometer can monitor a stream for six components.

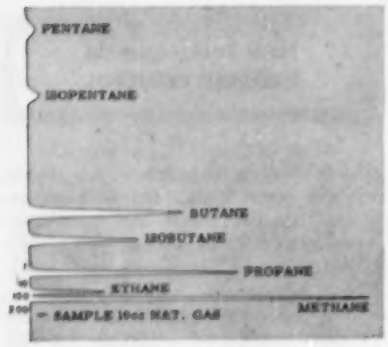

Fig. 12. Record of analysis of a multicomponent sample (natural gas) by vapor-phase chromatography.

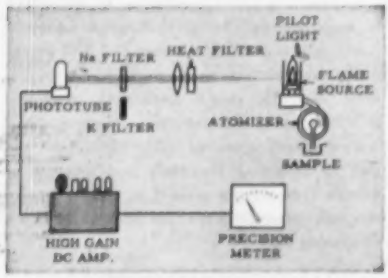

Fig. 13. Schematic representation of a direct-reading flame photometer.

Fig. 15. A fifty-channel data-handling system for a refinery installation.

of the thermal-conductivity type measures the separated fractions as they emerge from the column, not unlike cuts in an analytical distillation operation.

Figure 12 illustrates a record of the analysis of a multicomponent sample. The area under each peak is a function of the concentration of that component responsible for the peak. At the present time this technique is not being utilized for actual continuous-stream analysis; however, it is safe to predict that such an instrument will be available within the next year or so.

CONTINUOUS FLAME PHOTOMETRY

Most of the techniques mentioned deal with organic processes. To those involved in the inorganic chemical industry, a technique that is extremely interesting is continuous-flame photometry (Figure 13). In this operation a sample is continuously withdrawn from a stream, diluted accurately with a controlled stream of water, and then aspirated directly into a stable flame. The inorganic cations, when excited by heat, give off light, the wave length of which is dependent on the cation and the intensity, which is proportional to its concentration. Although this technique has been standard in the laboratory for some time, it is still in the experimental stage as far as a continuous process is concerned. Its range is tremendous; as little as tenths of parts per million of the alkalies and alkaline earths are measured directly, and through dilution concentrations up to 50 or 60% can be analyzed accurately.

CONTINUOUS pH MEASUREMENT

Most process engineers probably do not regard *p*H as a stream-analysis method. Actually, in many respects, this technique has not been fully utilized. There are many applications of continuous *p*H measurement (Figure 14) that are worth emphasizing. Some of these involve the use of a *p*H instrument in conjunction with a scrubber for measuring the acidity of gases. Another application is its use with a catalytic unit to combust organics followed by such a scrubber containing an electrode system.

Other applications of *p*H instruments are in the measurement of ions other than hydrogen. Electrodes are available that are responsive to chloride, bromide, iodide, fluoride, sulfide ions, as well as mercaptans and copper and silver ions. Chloride concentrations can be instantaneously and continuously recorded in the range of 0.1 to 10,000 p.p.m. Some installations based on this are actually on stream control. In one instance copper is the variable being measured and controlled in this manner.

Digital Data Logging

The eventual termination of the signals from most of the analyzers just mentioned is now in recorders. However, there is an entirely new philosophy of data recording now on the horizon; this is digital data logging. From the experience gained to date it would appear that data logging will influence process engineering in four ways:

1. as an aid in chemical engineering design in fundamental pilot plant research;

2. as an aid in the economics of production management;

3. as an efficient and convenient process monitoring and control mechanism;

4. as a principal component of automation.

Figure 15 shows a fifty-channel data-handling system which is about to be installed in a refinery. This system has an accuracy of 0.1% with a sensitivity of 1 μvolt, which, incidentally, is better than most of the end-point sensing elements now available. The scanning rate is 1 channel/sec., although the rate can be increased to 10 channels/sec. if desired.

Sample Handling

Perhaps the most important problem of all involving stream analyzers is sample handling. This must be thoroughly considered in all applications of stream-analysis instrumentation. These problems are difficult but can usually be overcome by the ingenious use of original engineering. Unfortunately, at present there is very little information in the literature on this aspect of the application of stream equipment. In general, it can be stated that the instrument manufacturers are well aware of the importance of this equipment and are making a very strong effort to aid the customer wherever possible. For some time to come, however, the burden of sample-handling equipment will lie with the user. No one knows his process as well as he does.

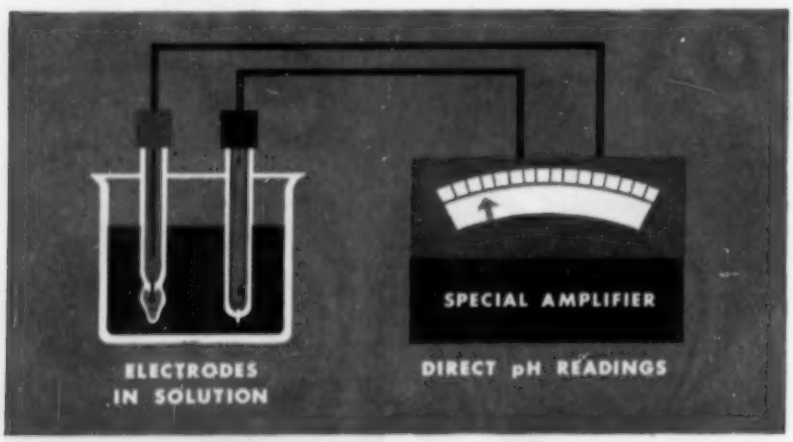

Fig. 14. Schematic representation of a system of continuous *p*H measurement.

Literature Cited

1. Kehoe, T. J., L. Silva, and H. J. Noebels, *J. Instrument Soc. America*, to be published.

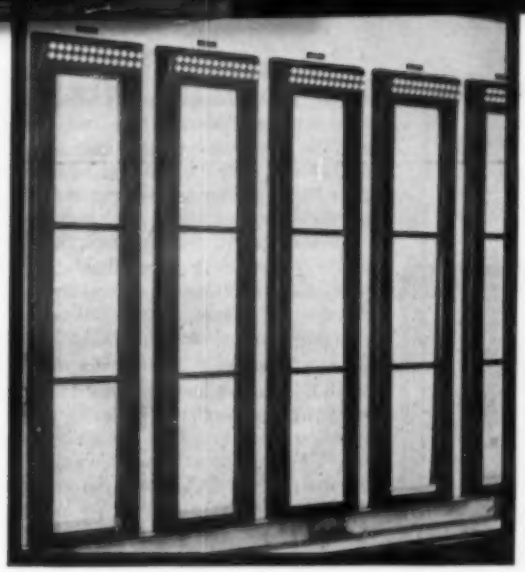

Fig. 3. Segmental recorders.

Many problems encountered in production reactor instrumentation have corollaries in chemical process plant facilities. Four examples of control systems are presented: monitoring flow in reactor cooling channels; monitoring temperature in the same channels; measuring the relative motion of reactor parts due to thermal expansion; and control of liquid level in a tank.

Instrumentation problems of PRODUCTION REACTORS

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A modern production reactor, which costs millions of dollars and develops millions of watts, is operated from a central control room by a team of five to ten men a shift. These men are, of course, backed by others engaged in routine preventive maintenance. Although there are others at the plant on whom they can call when difficulties arise, under routine conditions this small team operates the entire reactor. To do so, they must know conditions in all parts of the system. They must have information ranging in importance from reactor neutron flux to such minor items as the temperatures at the bearings of a remotely located motor-generator. In all, they must have current information on approximately 5,000 variables to start, operate, and shut down the reactor on a routine basis.

To provide the operators with these data presents two major instrumentation problems:

1. Radiation dangers seriously limit the types of instruments which can be used and their locations. Measurements must be made on process equipment located where no one can enter. Instruments, which in conventional applications would be mounted at the equipment, must be constructed to permit reading and maintaining them from a remote position.

Use of instruments which transmit to remote receivers might appear to answer the radiation problem. Unfortunately, nearly all transmitting instruments require regular maintenance. Despite the developments in robot devices which can work in radiation zones, it is simpler and more economical to locate an instrument where a maintenance mechanic can work on it directly.

Emphasis was, therefore, placed on locating the instruments and control equipment outside hazardous areas. Only simple, reliable, primary measuring elements such as orifice plates, dip tubes, thermocouples, and ion chambers were located within radiation danger zones. To the extent possible, even these devices were located where they would be accessible for limited periods with the reactor shut down. In rare instances it was also necessary to locate transmitting instruments in limited access areas. In such instances, two or more transmitters in parallel were provided such that if one failed, a stand-by could be used.

2. The sheer number of variables which must be watched and controlled presents a problem in itself. The whole purpose of the instrumentation is to guide the operators' judgment. The men must have information immediately in order to make decisions quickly and to take prompt action. They must not be encumbered by the task of continually taking thousands of readings to uncover abnormal conditions.

Several methods were used to concentrate the information and to assist the operators:

(a) The instruments were brought to the operators by transmitting the readings to receiving instruments located in a central control room.

(b) Graphic panels were used extensively. A panel of this type contains a large diagram of the equipment being operated. Receiving instruments are mounted at locations on the diagram corresponding to the locations on the equipment at which the transmitted measurements are made.

(c) Automatic control was used, where required, with provisions for remote manual control by the operators from the control room at any time.

(d) To digest the data further, most of the variables were monitored continuously and automatically. This system relieves the operators from the chore of watching continuously a large number of instruments whose readings are normal, and frees them to concentrate on conditions which may require instant action. Alarms notify the operators about abnormal conditions. In many cases two or more alarms in sequence were used, the first to alert the operator to the approach of trouble, the second to indicate a serious condition. If, despite the operator's effort, the condition becomes worse and the second alarm occurs, automatic action is taken to prevent damage to the equipment or to avoid dangerous power levels.

(e) With provision made for instruments, monitors to watch the instruments, and automatic controls to make corrections, their safety and reliability must be assured. Each automatic control system was so designed that should it fail, still a safe condition would prevail while a failure alarm would be actuated. The monitoring systems contained both fail-safe features and fault-detection devices.

Examples of the more interesting design problems and their solutions are presented below:

Cooling Water Monitoring

One of the most complex problems was that of detecting a small reduction in the flow of cooling water in any one channel through the reactor. A reduction in flow could cause local overheating to which the operators should be alerted as quickly as possible. A serious flow reduction would necessitate an immediate shutdown to prevent damage. Complete reliability of the instrumentation would be essential. It would be unsafe to operate the reactor if the instruments failed; this condition would result in a costly loss of production time.

Two principles could be used: (1) direct measurement of the flow in each channel, and (2) measurement of the temperature rise in each channel. In some channels temperature would be a more sensitive means of detection; in others, flow would be more sensitive. It

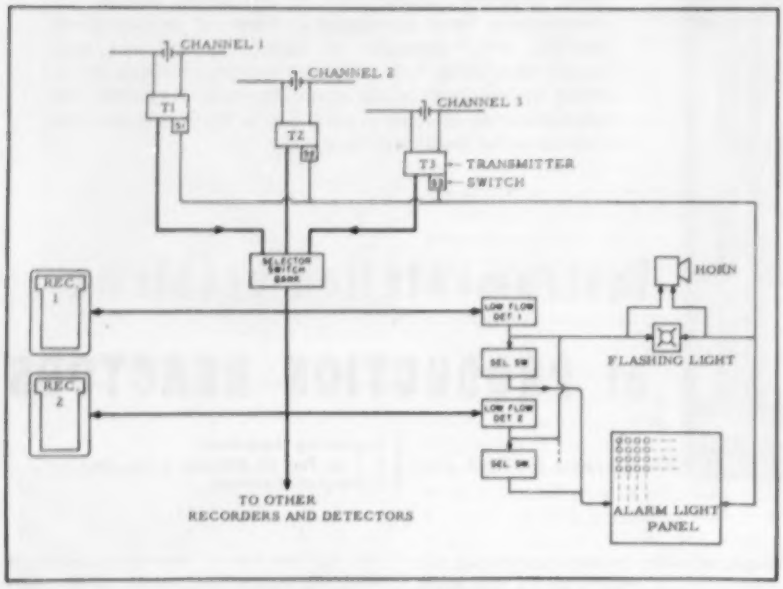


Fig. 1. Block diagram—flow monitor.

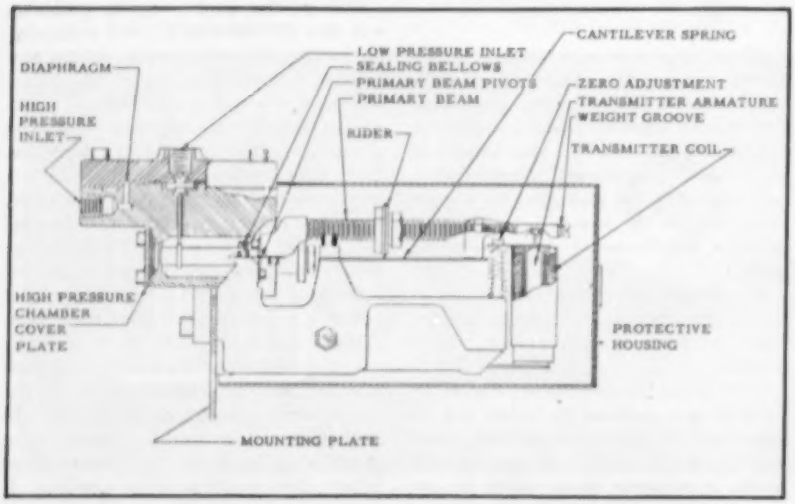
was decided to use both in order to have two independent measurements. Thus one measurement could be used to check the other, and to provide an alternate means of detection should one instrument fail. The temperature measurements could be used also to detect "hot spots" in the reactor caused by a high local fission rate.

Monitoring of these flows and temperatures illustrates the two major problems referred to above. (1) Radioactive water introduced difficulties in location and maintenance of the detecting instruments. (2) The excessively large number of separate measurements necessitated presenting the data to the operators in well-organized form so that they could find the location of a flow reduction or a hot spot quickly.

Flow Monitoring System

A block diagram of the flow monitoring system evolved is shown in Figure 1. The flow in each channel is sensed by an orifice. A transmitter measures the differential pressure across each orifice and sends a proportional 60-cycle electrical signal to the control room. Here signals from the transmitters come into a bank of selector switches, which automatically step from one transmitter to another in a continuous sequence. The output signal from each transmitter is switched simultaneously into an instrument which records the reading and into a low flow detector which operates an alarm horn and light. To identify the channel in which flow reduction is detected, a large board with a separate light for each channel is provided. A second bank of selector switches, mechanically connected to the first bank, permits the low flow detector to light the proper bulb. If flow in that channel decreases still more, a limit switch mounted on the transmitter closes, automatically shutting down the reactor. Each limit switch also operates a corresponding light on the alarm board, indicating which flow channel caused the shutdown.

Fig. 2. Differential pressure transmitter.



The differential pressure transmitter used in this system is shown in Figure 2. The design was chosen after careful evaluation tests in which the performance of every commercially available type was compared. Examination of the figure shows that an increase in the differential pressure causes the diaphragm to move upward, moving the primary beam about the cross-spring pivots. The bellows seal, which permits motion of the beam, actually consists of two bellows. One is built inside the other. Their bursting pressure is many times the normal operating pressure. Motion of the beam is opposed by a cantilever spring. Movement of the spring positions a powdered iron slug in the center-tapped coil, changing the inductances of the two halves of the coil. The inductances are used as two arms of a Wheatstone bridge in a remote measuring instrument. This design has three desirable features:

1. If the thin diaphragm fails, the liquid, which might be radioactive, is contained within the transmitter rather than leaking into the room.

2. By adjustment of the position of the rider on the beam, the differential pressure corresponding to full-scale motion of the coil slug can be adjusted over about a 5:1 range. This is quite useful since the channels may have different flows. In addition, there are differences in the individual orifice coefficients due to fabrication tolerances. By a positioning of the riders, all the transmitters can be adjusted to provide the same inductance at normal flow, enabling all to be recorded on a common chart calibrated in units of per cent of normal flow.

3. The calibration of the instrument may be checked and adjusted by hanging weights proportional to the product of diaphragm area and differential pressure on the right-hand end of the beam. Thus the calibration of any individual transmitter can be checked without disconnecting it from the cooling water stream and risking the dangers from leakage.

The transmitters are located behind a concrete shield wall, away from the radioactive cooling water flowing through the orifices. The activity in the water is caused by dissolved materials

of short half-life. The liquid in the lines between the orifices and the transmitters is essentially stagnant. The lines are of sufficient length, that by the time any material can diffuse through the lines past the shield wall, the activity has decayed to an easily tolerable level. A second concrete shield wall surrounds the room to protect the remainder of the building should contamination occur at the transmitters.

In design of the system it was considered desirable to record each flow automatically. Graphical recording was chosen rather than either continuous indication of each flow or digital recording by means of an electric typewriter. It was felt that an operator could ascertain from a glance at the graph the nature of past variations in flow. He could recognize new trends quickly. He could also predict future changes more accurately by extrapolation of a graph than by extrapolation from a list of past readings.

In order to compress a large number of graphic records into a small space, segmental recorders (*1*) are used. A group of these units is shown in Figure 3. The lights at the top indicate which point is being recorded. The charts are made in the form of endless belts or old-fashioned roller towels. A portion of a typical chart is shown in Figure 4. The horizontal width of this chart is divided into six equal columns. The vertical length is divided into 24 equal rows, two of which are shown. The chart is thus divided into 144 segments. The reading of an individual point vs. time is recorded in each segment. The number and the size of the segments are dependent on the readability required for the application. Up to 300 separate records have been legibly put on 10 ft. of chart paper.

These instruments use the recording mechanism of a standard recording potentiometer. The maximum speed of these mechanisms, commensurate with reasonable mechanical wear, is about 1 point/sec. Since it was considered essential to scan the entire group of flows every 2½ min., several recorders are used in parallel, operating simultaneously, and scanning repeatedly through 144 points. Therefore, the selector switch bank is divided into several sections, each section serving a separate recorder. Telephone-type stepping switches are employed.

The alarm lights are located on the panel in a graphic array. The layout simulates the location of the flow channels in the reactor. As shown in the block diagram, Figure 1, any light can be turned on by either the low flow detector or the switch on the transmitter. A novel circuit using only one bulb

Fig. 4. Segmental recorder chart.

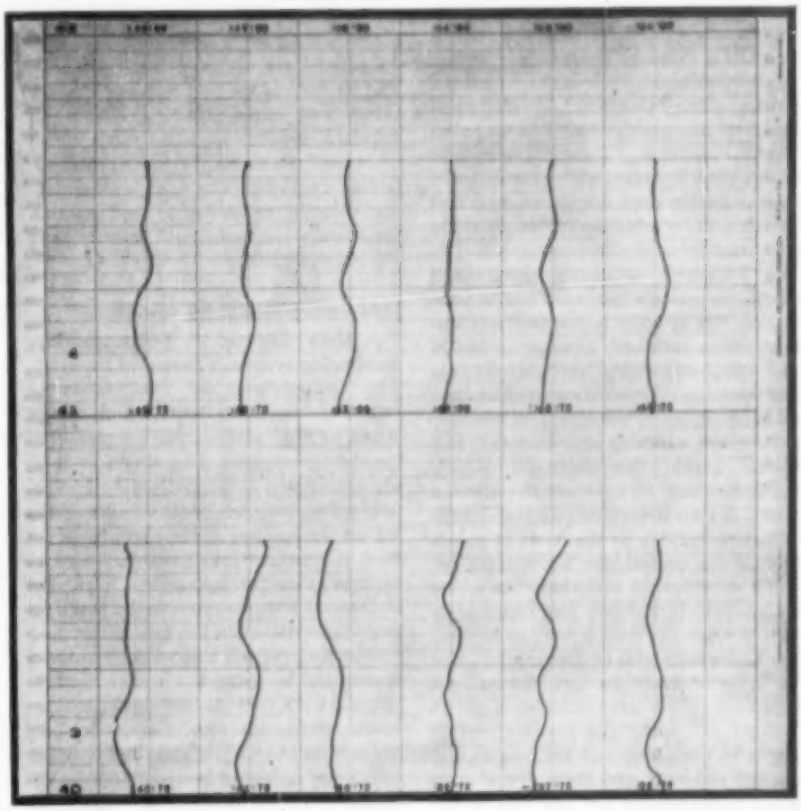
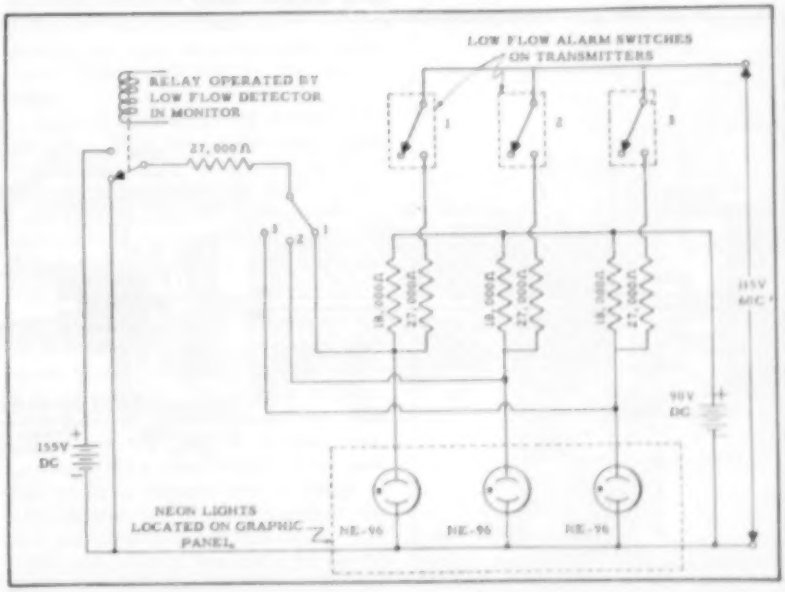


Fig. 5. Schematic diagram of alarm light circuit.



per channel is employed to indicate which alarm had been actuated.

A schematic diagram illustrating the principle of the alarm light circuit is shown in Figure 5. Neon glow bulbs are used for lights. These bulbs have the characteristic that the applied potential required to light them by ionizing the gas is greater than that required to keep them lighted. In the case of the type NE-96 bulb shown in Figure 5 the igniting voltage is 135 ± 15 v. d.c., compared to an extinguishing voltage of 75 ± 10 v. d.c. The characteristic orange glow appears only at the cathode. Thus only one electrode glows in direct current service, while both glow in alternating current service.

In Figure 5, a d.c. potential high enough to sustain but not initiate conduction (90 v. d.c.) is continuously applied across each bulb through an 18,000 ohm current-limiting resistor. If the flow measured by transmitter 1 is low, the alarm relay in the low flow detector is energized, applying approximately 155 v. d.c. across the electrodes, which causes the bulb to light. If the selector switch is then moved to position 2, bulb 1 remains lighted. If the flows at points 2 and 3 are normal, the alarm relay remains deenergized and these bulbs are not lighted. If the flow has returned to normal when the switch returns to position 1, the relay will be deenergized, and the relay contact reduces the voltage across the bulb to zero, turning it off. It remains off when the selector switch moves to position 2. If the flow in any channel suddenly decreases, the change is not discovered by the low flow detector until it again scans past that particular channel. However, if the flow decreases enough for the switch on the transmitter to close, an immediate indication occurs. An a.c. potential sufficient to fire the bulb is applied across it. One electrode glows if the bulb is fired by direct current from the low flow detector circuit. Both electrodes glow if it is fired by alternating current from the switch on the transmitter. Thus two indications are obtained from one bulb. The circuit has the disadvantage that the firing and extinguishing voltages of standard production bulbs vary somewhat, and thus require testing and selecting the bulbs. The firing extinguishing voltages change with age, so that periodically the bulbs must be tested and old bulbs replaced.

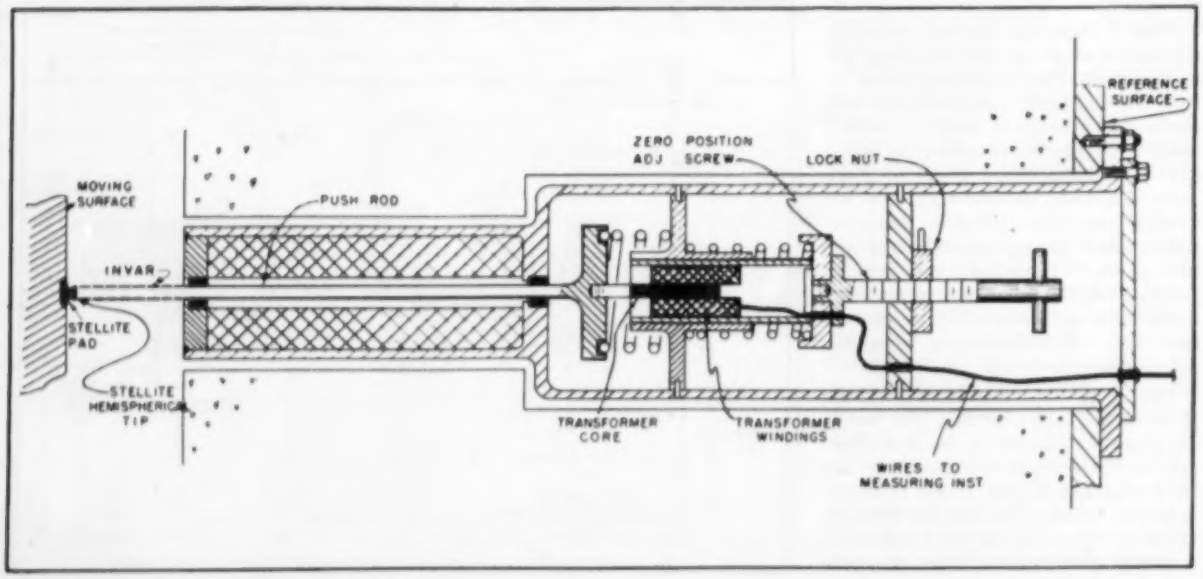
Temperature Monitoring System

A block diagram of the temperature monitoring system is shown in Figure 6. The temperatures of cool incoming water in the main header and of hot water leaving each channel are measured by thermocouples. The thermocouples are terminated in a junction box, carefully designed so that all junctions within the box are at the same temperature. Copper extension wire is used to connect the thermocouples from the isothermal terminal box to the banks of stepping switches in the control room.

The temperature rise in each channel is obtained by using the header thermocouple as the cold junction and the thermocouple in that particular channel as the hot junction. The stepping switches select the different hot junctions in sequence. The difference in voltage between the hot and the cold junction is sent to instruments which record the temperature rise in each channel. Segmental recorders, similar to those used in the flow monitor are employed. Operation of the two monitors may be synchronized so that flow and temperature are measured in the same channel at the same time.

Each thermocouple is also scanned by a second section of the monitor which actuates alarms if the temperature rise through any channel is greater or less than the normal value. Since the normal temperature rises in the several channels differ, the monitor has a separate alarm set point for each channel. This is accomplished by providing an electromotive force in series with each hot junction which may be adjusted to be equal and opposite to the e.m.f. between the hot junction and cold junction when the temperature rise is normal. An e.m.f. which is proportional to the deviation from the normal temperature rise is transmitted via the stepping switches into four parallel alarm channels. The high and low alarms warn the operator if any temperature rises are above or below the normal values by a predetermined amount. If the rise above normal becomes still greater, a second alarm is actuated and corrective action is taken automatically. If the temperature continues to rise actuating a third alarm, shutdown is automatically initiated. Neon alarm lights similar to those used in the flow monitor show the location of the channel which caused the alarm. The normal temperature rise is dependent on the power level at which the reactor is operating. Therefore, a control is provided which can adjust all of the normal temperature rise settings simultaneously to values correct for that power level.

Fig. 7. Linear differential transformer installation.



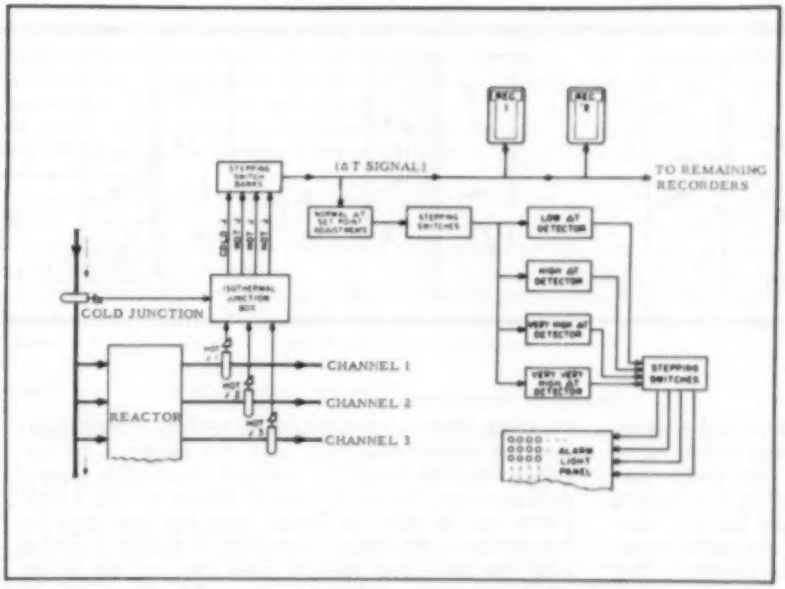


Fig. 6. Block diagram—temperature monitor.

Motion Measurement

The heat developed in a production reactor causes the reactor structure and its supporting members to expand. The expansion can cause changes in the clearances between adjacent parts. Various portions of the same part may expand unequal amounts, causing internal stresses. In many cases it is difficult to predict these relative motions and stresses accurately. Owing to these uncertainties, it is desirable to measure the positions of certain parts of the reactor when shut down and when operating at full power. This permits more accurate calculation of the maximum power level at which the reactor can be operated without exceeding safe stress limits. Three methods of measurement were used: (1) optical, (2) strain gauges, and (3) linear differential transformers.

The optical measurements employ cross-hair targets attached to reactor members. The targets are observed from outside the radiation danger zone by precision surveying instruments. This method is direct and accurate, but its use is confined to parts visible on the outside of the reactor.

Strain gauges, attached to surfaces which are expected to expand, may be placed in remote locations during construction of the reactor. However, these usually have poor resistance to radiation damage so that their use must be confined to shielded locations.

Linear differential transformers often can be used where neither of the above methods is suitable. This sensing device consists of a transformer having a movable iron core which changes the coupling between the primary and secondary windings and consequently the ratio of input to output voltage. By careful manufacturing techniques, the output voltage from the secondary winding can be made a linear function of the motion of the core. Relative motion of two parts can be measured by fixing the windings to one part and the movable core to the other.

A typical example is shown in Figure 7. Here the transformer windings are mounted inside a sleeve. The coil assembly is held firmly in position by a spring. Its initial zero position may be adjusted by a screw which is then locked in place. The movable core is attached to a push rod which is held by another spring against the surface whose relative position is to be measured. The transformer is located near the rear of the sleeve where it is shielded from radiation damage. Readings of relative position are made on a receiving instrument located remotely in the control room.

By such methods a total motion of as little as 1/16 in. can be measured within ±0.002 in., with the reference point several feet away from the moving point. Care must be taken to eliminate relative movement of parts within the measuring device and errors due to thermal expansion of parts.

Null Balance Liquid Level Control

In the reactor system it was necessary to effect close control of the liquid level in a storage tank. There were two variable flows of liquid into and one flow out of the tank, all at constant temperature. The liquid depth in the tank had to be adjustable over a range of several feet and held constant at the selected value within ±0.05 in.

Suitable control was achieved by the novel system shown in Figure 8. The level in the tank is controlled by varying the effluent flow. Flow is regulated by a valve operated by a pneumatic control system. A connection is made from the bottom of the tank to one side of a differential pressure transmitter. An air pressure, accurately controlled by a high quality regulator, is connected to the other side of the transmitter. The air pressure, measured by a manometer, is adjusted to be equal to the desired head of liquid in the tank. The difference between the desired head and the actual head is measured by a standard, industrial, differential pressure transmitter. It transmits an air pressure varying linearly from 3 to 15 lb./sq.in. gauge corresponding to differential pressures of −2 and +2 in. of water, respectively. The air pressure signal is transmitted to an industrial pneumatic controller with a set point of 9 lb./sq.in. gauge which in turn positions the valve.

Acknowledgment

The systems which have been described represent the teamwork of many men. The author has acted only as their spokesman. Included are those who first conceived the systems, those within the Du Pont Company and at vendors' plants who translated these concepts into detailed designs, those who installed and tested the finished instruments, and those who use the systems. All made significant contributions.

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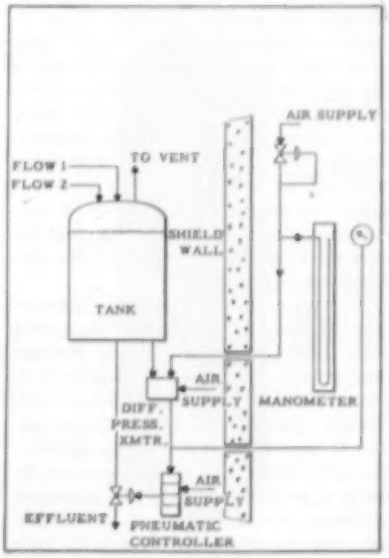
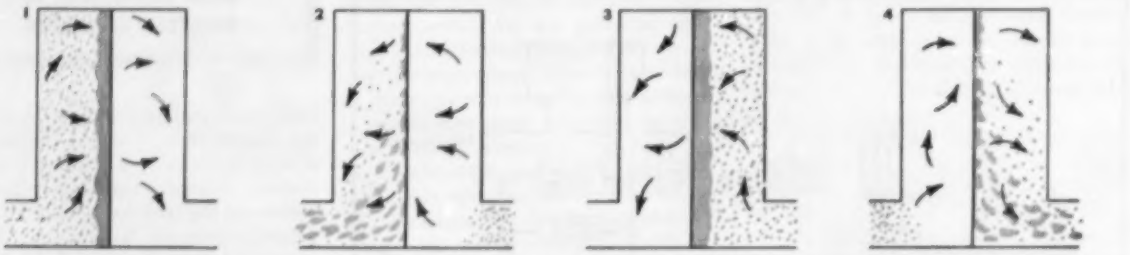


Fig. 8. Precision liquid level control.



Reversible filtration is characterized by a cyclical reversal of the direction of flow through the filtering medium without interruption for the removal of cake. The first portion of filtrate formed during a given period of flow in one direction serves as the backwashing fluid for the cake deposited on the cloth during the previous period when filtration was carried out in the opposite direction. The cake that has been backwashed off the cloth is carried out of the filter by the flow of filtrate. The cake is cut by backing screens and is removed from the filter as small pieces that act as individual particles with entirely different screening, filtering, centrifuging, or settling characteristics from the original feed. This cake can, therefore, be separated from the filtrate by standard liquid-solids separations processes. When the ratio of filtrate to cake is high, filtrate can be collected directly from the filter after the first portion of the filtrate formed per half-cycle is used to wash the cake and residual feed clear of the filtrate receiving chamber. Estimated reversible filtration costs based on clarification data obtained on a 0.8% solids feed indicate costs less than standard rapid sand filtration costs.

REVERSIBLE FILTRATION

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In the field of liquid-solids separations the most widely used processes are those utilizing a porous medium to retain the solids while the liquid is forced through the porous medium. This is known as filtration and ranges from what could be called wet screening at one extreme to the other extreme where precoats, filter aids, and very thin cakes are involved (*1*). In order to decrease the cost of filtration when separating materials of this nature that now require precoats and filter aids, an approach, aimed at decreasing the average cake thickness and improving cake discharging, is presented.

The approach to decreasing average cake thicknesses is closely associated with cake discharge. Since thinner average cake for a given process means shorter filtering times between discharges, the number of discharges per unit of time will increase. Frequent discharging of the filter cake has meant in the past increased labor costs, increased equipment costs, increased production loss due to downtime, and with particularly thin cakes more difficult cake discharging. To avoid these problems with cake discharge, yet to obtain the increased filtration rates associated with thin filter cakes, reversible filtration has been developed.

In all present processes filtration is carried out in one direction until the filter cake becomes thick enough to be discharged economically. The cake is then discharged by any one of numerous procedures. When the cake has been removed filtration is again started through the filter medium in the same direction as before.

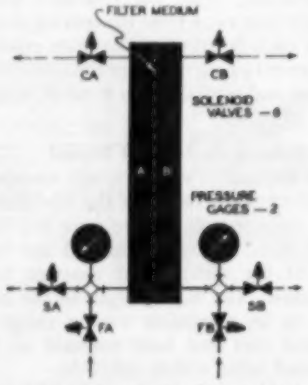

Fig. 1. Reversible filtration experimental unit flow diagram.

Process

The process that is described in this paper permits efficient complete discharge of thin filter cakes from one side of a filtering media with continuous cake formation on the other side of the filtration medium.

In reversible filtration the process is carried out in one direction in the same manner as present one-directional or direct filtration until a desired cake thickness has been obtained. Filtration is then started through the same filter medium in the reverse direction so that the filtrate as it forms, serves as the backwashing fluid. This procedure is continued alternating the direction of filtration in a cyclical manner. Reversible filtration is explained (see Figure 1) by the following typical steps based on a pressure-type filtration.

1. With the top, or clear discharge port, of chamber A (labeled valve CA) closed, and the bottom or sludge discharge port of chamber A (labeled valve SA) also closed, feed is forced into chamber A through the feed port (labeled valve FA). This pressurizes chamber A with respect to chamber B.

2. With valves FB and SB closed, and valve CB open, chamber B is at atmospheric pressure and fluid, or filtrate, is free to flow out through the top clear discharge valve CB.

3. Under this condition filtration will take place through the filtering medium separating chamber A and B. Cake forms on the A side of the filtering medium, or cloth, and filtrate passes through the cloth into chamber B and out the top valve CB.

4. When filtration has continued as long as desired, valve FA, the feed valve, is closed, and valve SA is opened. This releases the pressure in chamber A.

5. Valve CB is closed, feed valve FB is opened with SB still closed; this pressurizes chamber B by forcing feed into it.

6. Filtration then starts from chamber B to chamber A through the filter cloth separating the chambers.

7. As filtrate starts through the cloth it acts as a backwash, discharging the cake that had been deposited on the A side of the cloth during the previous half-cycle when the filtration was taking place from A to B (Step 1).

8. As this cake is removed from the cloth, all flow is out the bottom valve SA, carrying the cake with it.

9. As the filtrate flows through the cloth backwashing the cake in A, a new cake is formed on the B side of the cloth in direct ratio to the amount of filtrate that has passed through the cloth.

10. Where cake is discharged on the A side the resistance to flow is less than where cake remains on the A side. This results in higher filtration rates at the points of least resistance where the cake has been discharged.

11. At these points of higher flow, cake builds up on the B side faster than at points where cake remains on the A side. The resistance then increases at these points of higher flow and forces the flow to those sections where cake still remains on the A side.

12. This increased flow then forces off the remaining cake on side A. This process of plugging the flow where cake has been discharged then continues until all cake has been discharged.

13. Cake continues to flow out the bottom valve SA until chamber A is clear of all cake.

14. Valve SA can then be closed and CA opened allowing all remaining clear filtrate to flow out the top.

15. When filtration has been carried out as long as desired, the feed to the chamber B is shut off by closing valve FB and the pressure in B is released by opening valve SB.

16. Valve CA is then closed and FA opened.†

† The cycle has now reached the reverse of step 5 shown above and continues through step 16 with all references to A interchanged with B.

With operations as just described, the cake from the previous half-cycle is discharged at the same time as the initial filtration of the next half-cycle. While filtration is continued in repeating cycles, in first one direction then in the other, discharging of the cake takes place automatically without any additional operation. Cake discharging as a separate operation has been eliminated so that the effect of cake-discharging downtime is no longer a major factor in obtaining minimum cake thickness.

Experimental Equipment

The small experimental unit used in obtaining the data reported in this paper utilized a 1-in. by 9-in. filtering area of Feon 219 nylon filter cloth supplied by Filtration Engineers, Inc. This is a tight, strong cloth, with an ultimate strength of about 400 lb./in. parallel to the warp, and 200 lb./in. parallel to the fill of the cloth.

Both sides of the cloth were supported by standard 16-mesh galvanized 10-mil wire window screen (see Figures 2 and 3). These two screens were sealed to the cloth with soft rubber gaskets. Rubber gaskets were also used between the screens and the Plexiglas chambers. These chambers provided a closed volume on each side of the cloth and screens 1 in. wide, 9 in. tall, and ⅛-in. deep. Holes for a ⅛-in. pipe were located through the ¾-in. thick backs of the chambers at the top of the 9-in. open spaces. Holes for a ¼-in. pipe were located at the bottoms. This assembly then was held together by C clamps.

The filtrate exit solenoid valves were connected to the top ⅛-in. holes. The feed inlet, the sludge draw-off solenoid valves, and the pressure gauges were connected to the bottom ¼-in. holes by means of a pipe cross illustrated in the flow diagram, Figure 1.

A Moyno pump was used with a by-pass back to the feed tank for pressure control and agitation of the feed.

A cam-operated set of microswitches was used for operating solenoid valves.

Experimental Clarification Filtration

The feed was prepared by decanting the dispersed fines from a 50-lb. batch of International Talc Co. Asbestine 3X. This supernatant was allowed to settle again for 48 hr., and the fines again decanted off the top. The feed then consisted of solids that remained dispersed in the supernatant and averaged less than 1μ in size and contained 0.8% solids (8000 p.p.m.). A 7-min. half-cycle was used in which filtration took place continuously in one direction for 7 min. and then reversed and completed a single cycle of 14 min. The flow during the first minute of the half-cycle was collected separately as sludge-containing filtrate, residual feed, and cake. During the second minute the flow was separated and collected as cloudy filtrate. During the last five minutes the flow was collected as clear filtrate. A pressure drop of 30 lb./sq.in. was used for filtering.

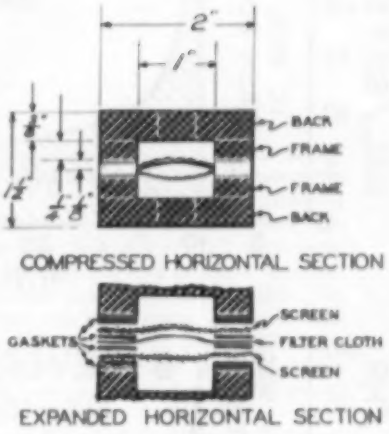

Fig. 2. Reversible filtration experimental unit—horizontal section.

At the end of this 9-hr. cyclic run of 38 cycles, filtration was continued in one direction for 20 min. in order to obtain a standard curve of filtration rate as a function of time. This is presented in Figure 4A as the cross-hatched area under the curve.

Figure 4 shows the importance of short cycles, cake thickness, and cake discharge based on experimental data obtained in the run described above. In Figure 4A a possible 60-min. cycle is shown for a standard pressure filter of the horizontal cylinder retractable leaf

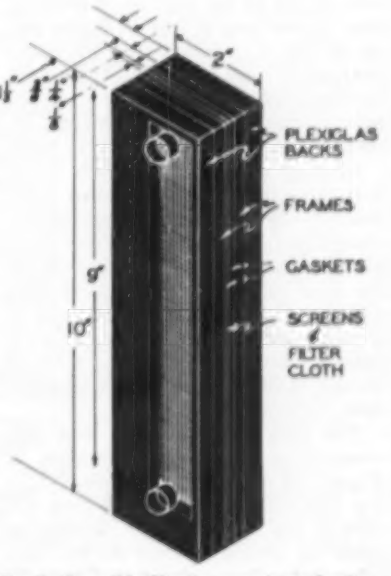

Fig. 3. Reversible filtration experimental unit—perspective view.

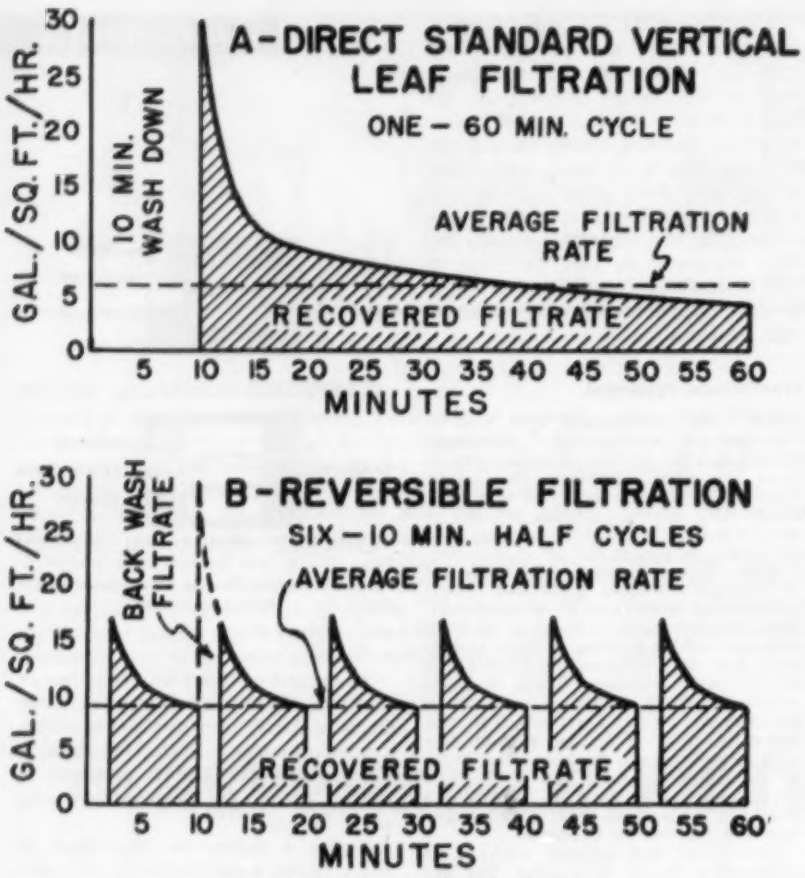

Fig. 4. Standard vs. reversible filtration cycles.

type. At the end of this cycle the filtration rate has dropped to 4 gal./sq.ft./hr.

In Figure 4B a series of six 10-min. reversible filtration half-cycles is shown with the use of the same basic filtration rate vs. time data as used in Figure 4A. At the end of each half-cycle the filtration rate is 9 gal./sq.ft./hr. This shows the importance of short cycles which do not continue the filtration through increasingly thicker cakes at slower rates.

In order to avoid these lower filtration rates due to thicker cakes, more frequent cake discharging must be accomplished. Reversible filtration (Figure 4B) has six cake discharges during the same period that standard filtration (Figure 4A) has only one. At end of a 10-min. reversible filtration cycle the cake is about 1/32-in. thick, while at the end of the standard 60-min. cycle the cake is about ⅛ in. thick.

The total time wasted in cake discharging in the standard filtration of Figure 4A amounts to 10 min./hr. In the reversible filtration of Figure 4B, 12 min. are wasted in cake discharging while not producing clear filtrate. One other factor that is shown in Figure 4B is that the first two minutes of filtrate formed in this reversible filtration run were used for back washing and were therefore basically wasted.

When these factors are all considered, the average filtration rates including lost time for cake discharging are shown as 6 gal./sq.ft./hr. for the standard filtration of Figure 4A, and as 9 gal./sq.ft./hr. for the reversible filtration of Figure 4B.

This shows that on this feed of 8000 p.p.m. solids reversible filtration can produce clear filtrate at a faster rate than can be obtained on a typical standard pressure-leaf filter of current design with a negligible labor requirement as reversible filtration is completely automatic.

Data presented in Figure 4 were used as the basis for an economical evaluation summarized in Table 1.

This cost evaluation uses a 100 p.p.m. of solids feed, rapid sand filter operation as a reference. This is done since it is a well-known universal operation. However, a much more attractive range of operation where reversible filtration may find its most effective applications is the presently avoided range indicated by H. P. Grace (*2*):

> The assumed concentration ranges typical of each type operation do not overlap and a concentration range of 0.1 to 1.0% solids by volume is not included in either. This is a region where the mechanisms of both types of operation are significant and is a region to be avoided. Although the equipment and methods suitable for either cake filtration or solution clarification can be applied to suspensions in this concentration range, neither is generally satisfactory nor economical. Thus, when faced with feed suspensions with 0.1% to 1.0% solid content, concentration by thickeners before filtration may be the best answer.

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2. Grace, H. P., *Chem. Eng. Progr.*, **47**, 502 (1951).
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Presented at A.I.Ch.E. meeting, Louisville, Kentucky.

Table 1.—Estimated Comparative Filtration Costs

water purification—3,600,000 gal./day

100 p.p.m. solids in feed—1 μ avg. particle size

	rapid sand filter (3)	reversible filter
Investment	$252,000	$84,000 (a)
Cost/million gal.	23.00	7.60
12% return on investment before taxes, overhead		7.50
Power		
Chemicals and labor	3.50	3.50
Total (b)	$26.50	$18.60

(a) Costs used here are approximations based on rate data presented in Figure 4 and corrected by theoretical relationships from 8000 p.p.m. to 100 p.p.m. solid in the feed and from 30 to 65 lb./sq.in.

(b) These figures should be used only to indicate (1) importance of reduced investment, (2) importance of power requirement, and (3) reasonable likeness of costs per million gallons.

SYMPOSIUM ON
OPERATIONS RESEARCH

A symposium of five papers stressing the practical use of operations research techniques in the chemical process industries will be held at the A.I.Ch.E. Pittsburgh National Meeting, September 9-12, under the Chairmanship of George D. Creelman.

A formally organized Operations Analysis ("Operations Research") Group has been in operation in the Engineering Department of the du Pont Company since early 1954. The Engineering Department operates du Pont's first large-scale digital computer on a service basis and provides consultation in a variety of statistical and mathematical fields. The Development Department conducts broad economic and organizational studies affecting company-wide planning policy. In addition, other departments have planning groups assigned similar responsibilities for the individual department; much of this work is equivalent to Operations Research. Just completed is an informal one-year's study of Operations Research possibilities conducted jointly by du Pont's Engineering, Treasurer's, and Development Departments. This presentation is a preliminary report on the study—neither wholly in favor of nor wholly against the use of Operations Research.

organizing for OPERATIONS RESEARCH

W. M. Carlson | E. I. du Pont de Nemours & Co.,* Wilmington, Delaware

Fig. 1. Construct a mathematical model of your operation.

Operations Research has passed through a period of unwarranted glamor as a great scientific discovery by the military which was to be a panacea for business ills. This tendency to overglamorize the term has hindered understanding in the chemical industry. This is owing principally to the fact that most chemical and petrochemical operations are approaching the automatic stage and are thoroughly instrumented so that engineers and managers of these operations are already quite familiar in their own work with such terms as "feedback," "data analysis," and "designed experiments." Moreover, workers in Operations Research have also generally failed to understand these characteristics of chemical industry and its management before approaching its problems.

Basically, the need of the chemical industry is to apply the same analytical tools to the administration of the business as are now applied to the conduct

* Engineering Service Division, Engineering Dept.

of chemical processes. Fortunately, because of the particular skills required, every well-operated chemical processing company already has people capable of understanding and using Operations Research techniques. Indeed, most chemical companies are using much of what is called Operations Research—whether or not they use the term itself.

Before organizing to use Operations Research, one must have the answers to a number of questions, of which the following five seem basic.

1) Why Are We Organizing?

Let us assume that your organization does not now have an activity that could be called Operations Research and that you want to know how to organize such an activity. The question of *why* you are organizing should then be pondered carefully, for it is an embarrassing one if not correctly answered at the outset. In Operations Research work, particularly, the usefulness of the study results bears a direct relationship to the degree that need for the study is recognized by management.

2) What Does Operations Research Help Solve?

This is undoubtedly the most critical question in considering how to organize to use Operations Research.

Broadly, Operations Research is most effective in solving problems that cross organization lines or that affect several similar operations; *technically*, it works best where mathematics can be used as a common language for communication; and *specifically*, it helps solve problems for the decision-maker because it introduces quantitative concepts that define his limits of knowledge and reduce guesswork.

Figure 2 indicates the contribution of Operations Research in the decision-making process. The man who has a problem and must make a decision calls normally upon the combined judgment, experience, and prescribed procedures of his organization to reach his decision. He knows a few things about the problem for certain and many things about which he is uncertain. When he reaches his decision, he relies heavily on his ability to guess, intuitively, the implications of known facts and the possible effect of unknown facts.

Operations Research provides a new path for him. This path, properly followed, provides a formal evaluation of all elements of the problem. It requires that the data used be sufficient to describe the entire problem and its solution. This tends to bring the whole problem into focus before the decision is made.

Figure 2 illustrates also the difficulties facing the Operations Research worker. He has to convince the decision-maker that it is worth the effort to go what seems to be the long way around. It is easy for people to see how they can jump from the problem to a conclusion using their own judgment and experience. It is not so easy for them to see how their solutions and decisions might be improved if they take the time to set up abstract mathematical models and use mathematical deduction or statistical induction to obtain a solution to their problem.

Difficulties such as these cause Operations Research to be used primarily to solve those problems that arise in the planning aspects of the business. The emphasis, therefore, is on long-range problems. Rarely will an Operations Research study provide a ready answer for day-to-day operating decisions until the problems involved persist to the extent of becoming a long-term deficiency of the business.

Some specific activities might indicate the problems that always require decisions in the chemical business. These problems show some promise of finding their solutions in the techniques of Operations Research because a full solution to them needs reliable evaluations of uncertainties. They may be classified as falling into the fields of research, manufacturing, sales, and administration. (See Table 1.)

These are all big, long-range questions involving major uncertainties about your customer, your competitors, and your own capabilities to produce. There is nothing unique about the list; these questions face everyone in business. Their universal nature gives Operations Research its best chance to show the extent to which it can help solve them.

3) What Do I Have to Learn?

Faced with this list of problems, we need the tools to solve them. Learning these tools and their uses is a lengthy, specialized task, and we will deal here less with these tools than with the attitude of mind that an organization needs to develop in order to use them.

Some expensive lessons in the need for a well-planned, quantitative approach from beginning to end in chemical engineering have been learned in the past. Operations Research work needs the same attention to basic data and careful measurement that sound chemical engineering requires. Unless you are resolved, as a first step, to be quantitative wherever possible, Operations Research won't help.

Much stress has been laid here on evaluation of uncertainties. The way to become quantitative about uncertainties is to state them in terms of their probabilities. Thus, the second step in acquiring the Operations Research philosophy is to obtain a basic appreciation of probability concepts and statistical

TABLE 1.

Where Operations Research May Give the Answer

IN RESEARCH

1. What are the unsatisfied and often unrecognized needs of our customers that require new or modified products?
2. Which of several alternative products or processes should be developed as giving best hope of success?
3. How do we split our effort between staying competitive in existing lines and opening up new lines?
4. When do we halt unpromising work?

IN SALES

1. How much would a better forecast be worth to me?
2. What steps should be taken to improve forecasting?
3. What is the true relationship between advertising and sales promotion and sales volume?
4. When is sales upturn or downturn significant enough to call for a realignment of sales effort?

IN MANUFACTURING

1. How much product do we store as inventory and in what locations?
2. Where do we make our products when several plants or machines are capable of doing it?
3. What variables in the process are really controlling my performance with respect to quality, capacity, and cost?
4. When, and where, do I replace existing facilities or construct additional capacity?

IN ADMINISTRATION

1. What criterion is the most effective and most sensitive measure of the organization's performance?
2. How should the organization allocate funds to provide for obsolescence of product or equipment?
3. Does the financial outlook for the company warrant a major commitment?

methods. Business situations change, and to be ready to measure their change for significance requires good statistical insight.

The question of the scientists' ethics needs earnest study for it involves one of the most important controversies over Operations Research methods. Some of the work being published makes good sense and appears scientifically sound. There are indications, however, that the field contains some relatively untrained people whose primary purpose is to use the novelty of Operations Research for personal profit and then to move on. Sound engineering analysis of a proposition and a careful application of the ethical standards of the profession will go a long way toward clearing up the unfortunate impression about Operations Research being created in some companies.

4) Who Can Help Me?

When you have the problem and have developed a sympathetic philosophy, the likelihood is that you will need substantial help in using Operations Research properly. Not only will you need help, but you will want to organize such help into a well-defined team.

The primary sources of help are, first, the basic team you will organize; then your group will want access to consultants outside your company and other segments of your own company. For best results over the long term, you will have to organize from within, and, as pointed out previously, chemical companies are well equipped with the right kind of personnel for such work.

Your internal study group should be headed by a man whom you trust to do your planning and whose appreciation for the scientific method is well established. It will have to include a man who knows, in intimate detail, the operation being studied. It will include people who can use mathematics and statistics with facility. And finally, it should have available to it some talent for computer programming to speed up the reduction of data to manageable form.

You should go outside the company to appropriate consultants when highly specialized assistance is not otherwise available to you. The three most frequent reasons for going outside in Operations Research are:

1. To get advice on how to set up the Operations Research approach.
2. To get highly specialized mathematical or statistical assistance.
3. To get computation help.

Finally, in getting help inside your company, you may consider the best sources as the treasurer, the research staff, and top management. The treasurer is particularly helpful; your study results are going to depend heavily on financial data his staff assembles and the cost data it approves. Get, and hold, the attention of the research staff; the data you unearth will nearly always have some effect on their planning. Finally, do not hesitate to talk Operations Research over with top management.

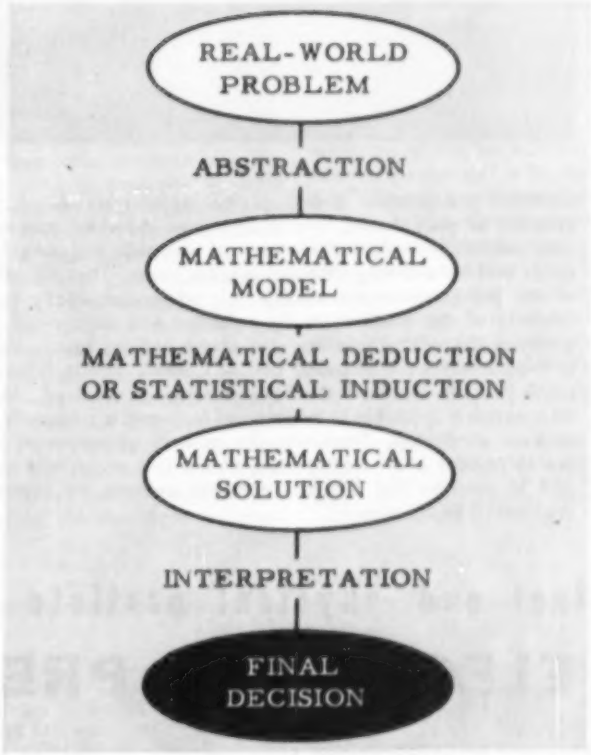

Fig. 2. The usual path from original problem to final decision is through judgment, experience and prescribed procedures. Operations Research opens up the new path graphically illustrated above.

5) When Is It Likely to Fail Me?

With an Operations Research organization constructed and launched with the blessing of management, with problems to work on and techniques to use, what are the difficulties that can wreck the program?

The following list is not all-inclusive, but it contains the chief things responsible for Operations Research failures:

1. When the job is turned over to an outsider without inside supervision.
2. When the man who pays for the study is unable to define the problem or identify the basis on which his decisions are made.
3. When your management decides to withhold any information about the business.
4. When the study report shows off its brilliant use of mathematics rather than concentrating on how much more money will be made.
5. When your record-keeping, such as cost data, reflects a static, "averaged-out" approach instead of a dynamic, objective system. (For example, linear programming is of little help if cost data cannot define the effects of incremental production or sales.)
6. When the study group tries to usurp any of the decision-making powers of the organization under study.

As a separate, identifiable technology, Operations Research is still on trial in industry and will remain so for some time. Du Pont is using parts of this new technology, both with and without the aid of the computer, and expects to gain from the adventure. The many problems facing Operations Research are a challenge to our ingenuity and our integrity, because when all of the conditions for its success are achieved, our businesses will be healthy indeed.

Presented at A.I.Ch.E. meeting, Galveston, Texas.

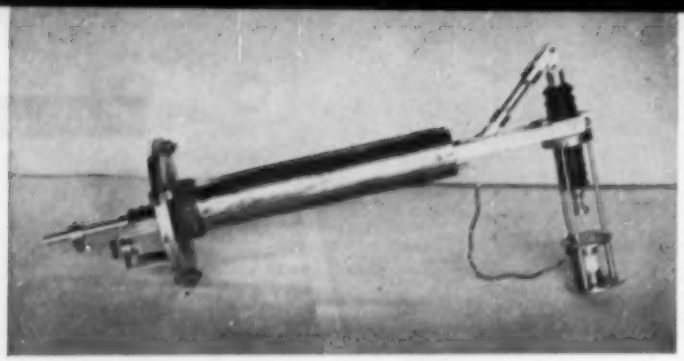

Fig. 3. Portable probe for field measurement of particle resistivity.

Electrical precipitation is one of the major methods of controlling emission of dusts, fumes, and smokes from industrial operations. It is also used extensively for recovery of valuable materials from stack gases and for cleaning chemical process gases. That the effectiveness of the precipitation operation is related fundamentally to the conductivity of the particles to be collected was recognized early (1), although the relationship was one of the baffling factors encountered in the pioneer work of Lodge and of Cottrell. It has, however, taken many years to elucidate the basic phenomena involved. Most of this information is available in fragmented form and is frequently confusing or even conflicting. Therefore, the primary objectives of this paper are to present a coherent picture of the role of particle conductivity and to describe and evaluate practical methods for overcoming the problem of high resistivity.

chemical and physical particle conductivity factors in

ELECTRICAL PRECIPITATION

H. J. White | Research-Cottrell, Inc., Bound Brook, New Jersey

In the electrical-precipitation process the gas to be cleaned is passed between highly charged electrodes which are usually in the form of coaxial wires and cylinders or of parallel wires and plates. Gas ions are formed in the high field regions near the wires and flow to the grounded pipes or plates. These ions, which are vital to the process, serve to charge the suspended particles in the gas as well as to promote collection of the particles on the ground electrodes.

However, as the ion densities produced in the treatment zones of a precipitator are enormously greater than the particle densities of even the most concentrated aerosols encountered in practice, only a minute fraction of the ions are used to charge the particles electrically. The bulk of the ions flow to the ground electrodes in the form of a d. c. corona current. This corona current must pass through the particle deposits which form on the ground electrodes as a result of the collection process.

It is clear that these particle layers must possess at least a small degree of electrical conductivity in order to conduct the corona currents to ground. The minimum conductivity required as shown by both theory and experience is about 10^{-10} inverse ohm-cm. (*2*), which from a practical viewpoint amounts to merely a trace conductivity when compared to the conductivities of ordinary metals or even of electrolytes* but is much greater than the conductivity of good electrical insulators.†

Particles having conductivities of less than the critical value of 10^{-10} are referred to as *high-resistivity* particles, the critical minimum value of resistivity being about 10^{10} ohm-cm.

In precipitator operation high particle resistivity is usually manifested by disturbed electrical conditions in the form of excessive sparking at somewhat lowered voltages or by excessive current at greatly lowered voltages. These effects in turn cause loss of precipitator efficiency, the loss in performance increasing with resistivity. When resistivity exceeds about 10^{11} ohm-cm., it becomes very difficult to achieve reasonable efficiencies with precipitators of conventional design.

* Conductivity of copper = 6×10^5 at 20° C., of a 5% HCl solution = 2.5 at 20° C.

† Conductivity of sulfur ≅ 10^{-17} at 20° C. in dry atmosphere.

Types of Particles Encountered

Most liquid particles and certain types of solid particles are intrinsically conducting and therefore cannot cause difficulty because of high resistivity. Most of the dusts and fumes met with in industrial precipitation applications, however, originate from furnace, smelting, drying, or calcining operations and are composed of silicates, metallic oxides, and similar inorganic compounds. Many of these materials in the pure dry state are among the best insulators known and therefore might be expected to cause trouble in precipitators. In the majority of actual cases, however, moisture and chemical impurities are present naturally in sufficient degree to provide the trace conductivity required. In some cases the gas temperature may be high enough to ensure adequate conductivity in the particles by the temperature-conduction effect, which is explained below.

Low moisture and absence of certain specific chemical impurities, coupled

with temperatures in the range of 250° to 450° F., are likely to cause high-resistivity particles, but in practice these are encountered in not more than about 10 to 15% of all electrical-precipitation applications. Most of these troublesome cases can be successfully handled by the conditioning methods to be explained, unless economic or operating factors prevent their use. Although the percentage of high-resistivity cases is not large, it is essential that practical methods be available for reducing particle resistivity where needed, particularly as these cases are not always predictable.

Intrinsic or Volume Conduction

The electrical conductivity of a bulk layer of particles depends on both surface and volume factors. In surface conduction, electrical charges are carried in the surface films surrounding the particles. These films usually differ both physically and chemically from the interiors of the particles owing to adsorption phenomena. Volume conduction, or the motions of electrical charges through the interiors of the particles, depends, on the other hand, on the composition and temperature of the particles. It is apparent that volume conduction also involves ancillary factors such as compactness of the particles, particle size and shape, and surface properties. These factors are insignificant in cases of high particle conductivity, which need not be discussed here.

Investigation has shown that conduction in semiinsulating mineral particles may be either ionic or electronic (*3*). The most common examples of ionic conduction are in metallic halides, such as sodium chloride or silver bromide, which are of little importance in electrical precipitation. Electronic conduction occurs in many materials such as metallic oxides and silicates which are of primary interest in industrial gases.

It has long been known that the resistance of semiinsulators such as glass or ceramics decreases with rising temperature (*4*). The rate of decrease varies with the material but for most materials follows an exponential law which can be derived from quantum mechanical principles (*3*) in the form

$$\rho = Ae^{B/kT} \qquad (1)$$

Investigations indicate that the resistivities of most industrial dusts and fumes as measured in the laboratory with atmospheric air may be represented with reasonable approximation by Equation (1) for temperatures above about 250° F., where volume conduction predominates.* Experimental results for several representative dusts are plotted in Figure 4. It will be noted that materials having high resistivities also have lower slopes; in fact, the relationship appears to be quantitative, as shown in Figure 5. Also it may be observed

* As explained in the next section, surface conduction is negligible above about 200° to 250° F. when the ambient gas contains only about 1% moisture, as is the case for ordinary atmospheric air.

HOW TO MEASURE PARTICLE RESISTIVITY

Quantitative determination of particle resistivity usually requires a special high-voltage conductivity cell.

One type of laboratory cell used by the author is shown in Figure 1. The cell is mounted in an electrically heated and thermostated oven capable of reaching temperatures of 600° to 700° F. A particle layer several millimeters thick is generally used. The layer may be placed on the plate electrode manually or else precipitated on by means of a d. c. corona from the high-tension point. The high tension disk electrode is lowered on the dust layer for the actual resistivity measurement.

In another type of cell, humidity as well as temperature may be controlled, with humidity values ranging from bone dry up to 30 or 40% by volume. The higher humidities are possible, of course, only for temperatures above the dew point.

The schematic electric circuit used with these cells is shown in Figure 2. The electrometer is sensitive to 10^{-12} amp., permitting measurement of resistivities as high as 10^{15} ohm-cm. Field measurements of particle resistivities in plant flues may be made by use of a compact, light-weight apparatus similar in principle to that used in the laboratory (Figure 3). The cell may be shielded against direct gas impact where high gas velocities are met. In another arrangement gas may be withdrawn from the flue through a side chamber and resistivity measured under controlled lower gas velocities.

Experiment shows that the resistivity depends somewhat on the compactness of the particle layer and also on the applied voltage. The compactness effect normally may introduce an uncertainty factor of about two in the measured resistivity. Applied voltage is limited by breakdown or sparking through the layer. The breakdown strengths of particle layers usually range from a few hundred volts per centimeter to 10 or 20 kv./cm., with the latter being more common. Since the current through a particle layer usually increases somewhat faster than the applied voltage, the measured resistivity will be lower at higher voltages; therefore resistivity measurements generally are made at voltages near breakdown or at least at values corresponding to a field strength of a few kilovolts per centimeter.

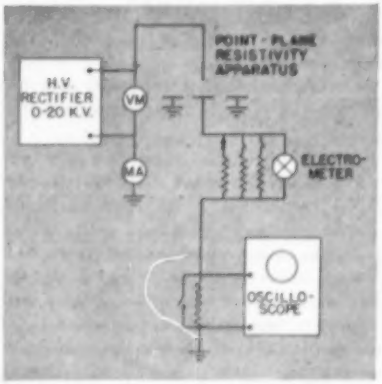

Fig. 2. Schematic circuit diagram for dust-resistivity apparatus.

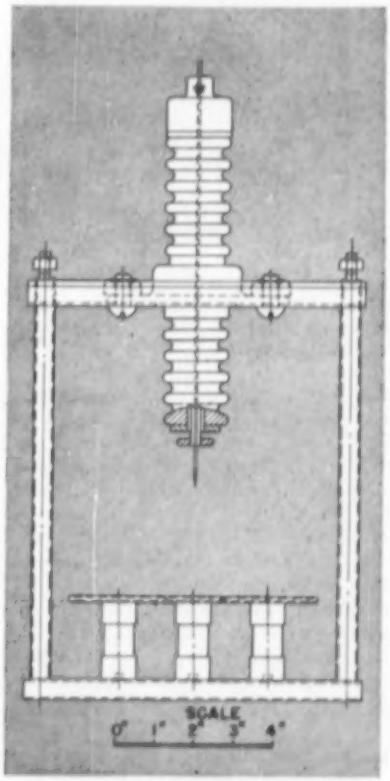

Fig. 1. High-voltage cell for measurement of dust resistivity.

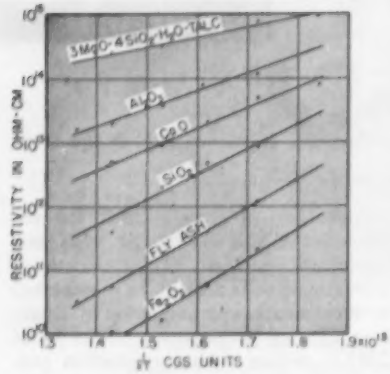

Fig. 4. Semilogarithmic plots of particle resistivity as a function of 1/T.

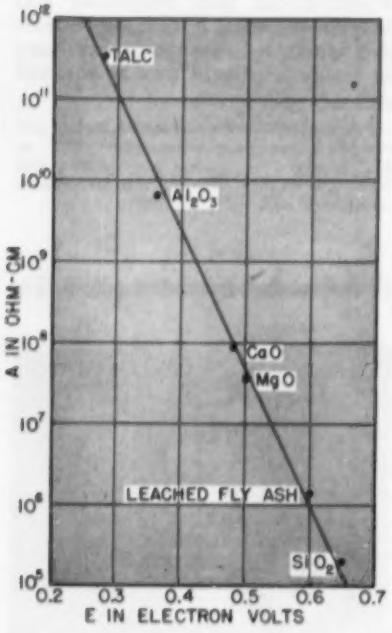

Fig. 5. Experimental relationship between parameters A and E in resistivity Equation (1).

that the values of the electron activation energies E all lie within the range of 0.12 to 0.8 electron-volt.

From the foregoing results, it appears that the volume conductivity of dusts and fumes is caused by temperature excitation of internal electrons. The conductivity increases rapidly with temperature in accordance with Equation (1). Field measurements also confirm the increase in particle conductivity and the improved performance of precipitators collecting these materials at higher temperatures.

Surface Conduction

Surface conduction usually predominates for semiinsulating particles in the lower temperature range below about 300° to 400° F. As previously noted, conduction at these lower temperatures occurs primarily through adsorbed moisture and chemical films on the particles. Moisture is present naturally in most industrial gases controlled by electrical precipitation. These gases usually result from processes in which moisture is produced from combustion of hydrocarbons, from drying or calcining of raw materials, or by direct use of water in the process. In practice, the moisture content of the gases ranges from a few up to about 50 per cent.

MOISTURE CONDITIONING

Conditioning of gases by steam injection, water sprays, or wetting of raw materials to reduce particle resistivity is widespread, particularly where the natural moisture content of the gas is low and the temperature relatively high. Moisture also raises the dielectric strength and reduces the viscosity of the gas.

Water adsorption on particles varies directly with the moisture content of the gas and inversely with the temperature, in agreement with elementary adsorption theory (*5*). Hence, conditioning by humidification is always more effectual at low temperatures. At room temperatures, for example, most dusts and fumes may be effectively conditioned by only 1 or 2% moisture in the gas, but the amount of moisture required rises to 10 to 20% for temperatures of 200° to 300° F. Nevertheless, moisture conditioning will in some cases produce an important effect at temperatures as high as 500° or 600° F.

CHEMICAL CONDITIONING

Chemical conditioning agents have also found considerable application but have definite limitations owing to cost, application factors, and the difficulty of finding suitable materials. Although some fundamental concepts are useful guides to finding effective chemical conditioning agents for given problems, the discovery of agents is at best semiempirical.

Chemical conditioning agents may be effective in fantastically minute concentrations.

A good example occurs in the fine cleaning of the exhaust gas in the powdered-catalyst petroleum cracking process used widely in the production of high-octane gasoline. In the first full-scale operation of this process, during the early days of World War II, it was found that recovery of the valuable aluminum silicate catalyst dust in the electrical precipitator was hampered by high resistivity of the particles. When NH_3 was found to be a highly effective chemical conditioner, it was added to the precipitator gas in the proportion of only 1 part in 50,000, sufficient to drop the dust resistivity from 5×10^{11} to 10^{10} and to raise precipitator efficiency from 96 to 99.8%.

The solution in this case was simple, easily carried out in practice, and low in cost relative to the improved performance obtained and to the value of the additional dust recovered. Unfortunately the discovery of suitable conditioning agents is not always so easy. Sulfuric acid, which has proved effective for various smelter fumes (*6*) as well as for fly ash (*7*), is used extensively in smelters but has not proved acceptable in the power industry, where SO_3 injection poses a difficult operating problem. Chlorides such as sodium chloride and calcium chloride have found limited use in the conditioning of certain oxide dusts and fumes (*8*). Oil or hydrocarbon vapors have also proved successful in a few cases (*9*).

Moisture appears to be essential to the effectiveness of chemical conditioning agents. In general, the action of the conditioner increases with the amount of moisture in the gas and with decreasing temperature of the gas. Water vapor therefore is frequently referred to as a primary conditioning agent and chemical conditioners are considered secondary conditioning agents. The surface conductivity of particles in all cases seems to be due to the presence of adsorbed moisture films, with the secondary conditioning agent acting as a binder between the particle surfaces and the moisture films.

Theories of surface conduction on insulating substances involve adsorption phenomena, including both physical and chemical adsorption. Physical adsorption is characterized by relatively low binding energies of the order of a few thousand calories per mole of adsorbate. Chemical adsorption, on the other hand, typically involves binding energies of the order of some tens of thousands of calories per mole. This provides a qualitative basis for understanding the action of chemical conditioners. Adsorption of a moisture film on chemically inert surfaces will be by physical or van der Waal's forces only and therefore rather weak. Interposition of a chemical binder, which is strongly adsorbed on the surface and in turn strongly adsorbs moisture, will result in much greater binding forces and more effective conditioning. In all cases conduction in surface moisture films appears to be electrolytic or ionic in character, with the proton-jump mechanism (*10*) being the predominant mechanism for transfer of charge.

Theoretical calculations indicate that moisture films only a few molecules thick are adequate to provide the desired surface conductivity. Measurements of the moisture contents of dusts agree with this conclusion; for example, moisture contents of conductive fly ash have been found to be typically 0.1 to 0.3%. The specific surfaces of these ashes are about 5,000 to 10,000 sq. cm./g. Then an elementary calculation leads to values in the range of five to ten molecular layers for the thickness of the surface moisture films. This is on the assumption that all the moisture is present in adsorbed form.

Surface conduction on particles is

closely related to surface leakage currents occurring on electrical insulators, which have been extensively studied (*11*). The controlling factors are similar to those found for surface conduction on particles. An interesting practical application of surface leakage is the determination of dew point by measurement of the current between adjacent electrodes mounted on a glass surface. A sharp rise in current signals the formation of a moisture film on the glass. This method has been used effectively for determining the marked rise in dew point which occurs when small amounts of sulfuric acid are added to an atmosphere (*12*).

Conditioning by Admixture of Conductive Particles

The conductivity of insulating particles may be effectively increased by the addition of relatively conductive particles in finely dispersed form. The effect is purely physical in nature and usually requires fairly large amounts and uniform mixing of the conductive aerosol to be effective. Very fine dispersoids such as carbon black or black smoke tend to coat insulating particles with conductive layers and therefore may be effective in small amounts of only a few per cent. On the other hand, coke particles, which are much coarser than carbon black, may require 10 or 20% or even more, relative to the weight of insulating dust, to be effective.

It is important to note that the conditioning effect obtained by the admixture of conductive particles is basically different from the effects produced by moisture or chemical conditioning. There is no increase in the conductivity of the primary particles per se, but, rather, parallel paths consisting of contiguous chains of conductive particles are established in the precipitated dust layer. The rather large amounts of conductive material required coupled with the uncertainties which result from selective collection of the conductive particles greatly limit practical applications of this method.

Typical Resistivity Data

A typical resistivity-temperature curve for fly ash taken in the laboratory at room humidity of about 1% by volume is shown in Figure 6. The resistivity is about 10^9 at room temperature, rises steeply to a maximum of about 10^{12} at 120° C., and then falls with further increase in temperature, again reaching the value of 10^9 ohm-cm. at 375° C.

The general form of the curve may be explained as follows: at room temperature the particles adsorb appreciable moisture from the air and therefore have a relatively low resistance. As the material is heated, the adsorbed moisture is driven off and the resistance increases rapidly. At higher temperatures the resistance falls owing to temperature excitation of electrons in the particles. The curve thus delineates the two basically different types of conductivity mechanisms present in the dust, namely, surface conduction in the lower temperature range and volume conduction in the higher temperature range.

Figure 7 shows the effect of previous treatment on the resistivity of a typical fly ash. The ash was heated slowly and then cooled in a laboratory oven, resistivity measurements being made at intervals on the cycle. The higher resistivities and shifted peak of the cooling curve are explained by the driving off of adsorbed moisture during the heating period.

Washing the ash in distilled water and redrying in an oven at 220° F. removed about 3% as a water-soluble fraction and caused the resistivity to jump by a factor of 10 to 100 times. Investigation showed that the jump was caused by removal of a sulfate film from the surfaces of the particles. This sulfate was present naturally on the ash and acted as a chemical conditioning agent to lower resistivity greatly.

Figure 8 illustrates the effect of moisture content of the ambient gas on the resistivity curve. With bone-dry air the resistivity continues to rise exponentially even while the temperature falls to room level, an indication of total lack of surface conduction. On the other hand, even 1% moisture in the air is sufficient to cause a rapid decrease in resistivity at temperatures below 220° F. owing to surface conduction. With 3% moisture the peak of the resistivity curve is moved to the higher temperature of 270° F. This experiment illustrates the fact that the peak of the resistivity-temperature curve occurs at higher temperatures but has lower values as the moisture content of the ambient gas is increased and also that with bone-dry gas no peak occurs, but resistivity continues to rise with decreasing temperature.

This laboratory investigation of resistivity has also included measurements on chemically prepared powdered samples of typical oxides and silicates similar to those commonly encountered in practice. Both reagent and technical grades have been studied. Results for a number of materials are shown in Table 1 for temperatures from 70° to 500° F. and atmospheric air with about 1% moisture. A comparable list of resistivities measured in the same manner for dusts and fumes collected in the field for filter-thimble sampling of flue gases is shown in Table 2. The general similarity in results in these two tables with the resistivity-temperature curves already discussed is apparent.

Although laboratory studies of particle resistivity are essential for basic understanding of the physical and chemical phenomena involved, field resistivity measurements made in plant flues are more important in practical applications. Such measurements have been made in

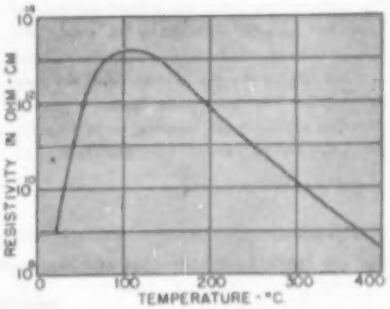

Fig. 6. Resistivity-temperature curve for typical fly ash heated in laboratory oven.

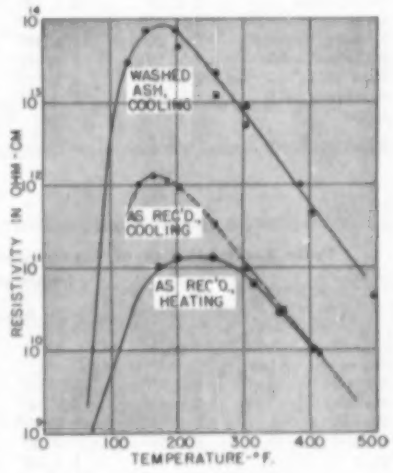

Fig. 7. Effect of preheating and leaching on resistivity of typical fly ash.

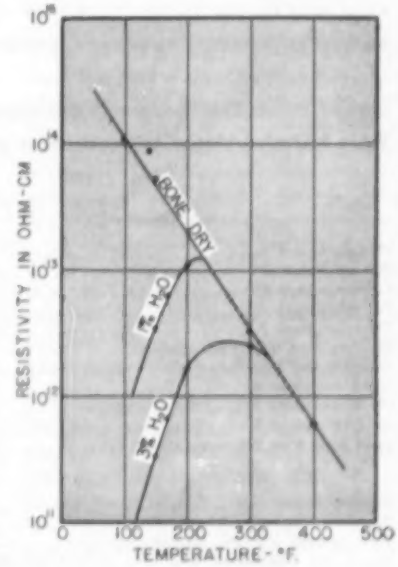

Fig. 8. Effect of air humidity on particle resistivity.

a wide variety of plants over a period of years, and a reasonably good pattern of the results has been obtained.

Typical values are summarized in Table 3. The majority are below the critical resistivity of about 10^{10} ohm-cm., although a few exceed this value. Note particularly the effect of cooling and humidifying the gas in decreasing the resistivity of the lead fume. Also worthy of note is the effect of raising gas temperature in dropping the resistivity of cement kiln dust (plant A). These are practical illustrations of conditioning by moisture to increase surface conduction and by temperature to increase volume conduction of particles.

Future lines of investigation in this field may be expected to include the following items:

Research on particle adsorption and methods of increasing surface conduction through such techniques as radioactive tracers, infrared spectroscopy, and microchemical and microphysical measurements.

Further work on scientific methods for finding effective chemical conditioning agents for specific types of particles.

Development of precipitators which will function effectively with high-resistivity particles of 10^{11} or even 10^{12} ohm-cm., which is about the highest value encountered in practice.

Table 1.—Resistivities of Representative Metallic Oxides, Silicates, etc.

Material	Resistivity, ohm-cm. Temperature, ° F. (heating cycle) 70	150	250	350	450
Ferric oxide	3×10^{7}	2×10^{9}	9×10^{10}	1×10^{13}	1×10^{10}
Calcium carbonate	3×10^{8}	2×10^{11}	1×10^{12}	8×10^{11}	1×10^{12}
Titanium dioxide	2×10^{7}	5×10^{7}	1×10^{9}	5×10^{8}	4×10^{9}
Nickelous oxide	2×10^{6}	1×10^{8}	4×10^{8}	2×10^{8}	6×10^{4}
Lead oxide	2×10^{11}	4×10^{13}	2×10^{12}	1×10^{11}	7×10^{8}
Aluminum oxide	1×10^{8}	3×10^{8}	2×10^{10}	1×10^{12}	2×10^{12}
Sulfur	10^{14}				

Table 2.—Resistivities of Representative Dusts and Fumes Collected from Industrial Plants

Material	Resistivity (heating cycle), ° F. 70	150	250	350	450
Fly ash	8×10^{8}	8×10^{8}	8×10^{8}	1×10^{9}	1×10^{9}
Fly ash	3×10^{9}	5×10^{9}	2×10^{11}	4×10^{11}	1×10^{11}
Fly ash	2×10^{10}	3×10^{11}	7×10^{12}	5×10^{12}	7×10^{11}
Cement dust	8×10^{7}	7×10^{8}	7×10^{10}	3×10^{11}	9×10^{9}
Lime	1×10^{9}	1×10^{9}	1×10^{11}	3×10^{11}	1×10^{11}
Alumina fume	3×10^{8}	3×10^{11}	2×10^{12}	5×10^{10}	8×10^{9}
Chromium oxide dust	2×10^{9}	4×10^{9}	2×10^{10}	9×10^{10}	3×10^{10}
Scarfing machine dust	2×10^{9}	3×10^{11}	1×10^{11}	7×10^{8}	8×10^{7}
Open-hearth dust	1×10^{9}	3×10^{9}	3×10^{11}	1×10^{11}	9×10^{9}
Nickel oxide kiln dust	3×10^{10}	8×10^{9}	6×10^{9}	5×10^{9}	1×10^{9}

Table 3.—Resistivities of Industrial Dusts and Fumes Measured in Situ in Plant Flues

Plant and dispersoid	Gas temp., ° F.	Moisture content of gas, % by vol.	Resistivity, Ohm-cm.
Fly ash—plant A	320	....	2×10^{10}
Fly ash—plant B	360	....	5×10^{9}
Fly ash—plant C	540	22.0	10^{10}
Fly ash—plant D	250	....	10^{9}
Fly ash—plant E	430	....	5×10^{9}
Gypsum dust from flash calciner	340	30.0	10^{12}
Gypsum dust from rotary kiln	300	31.0	7×10^{9}
Cement—plant A	470	....	10^{10}
Kiln—plant A	570	41.0	5×10^{7}
Dust—plant B	340	4.5	2×10^{10}
Lead fume from D-L sinter plant	290	10.0	10^{10}
	125	9.0	2×10^{10}
	104	7.5	10^{9}
Copper roaster dust	290	22.0	2×10^{9}
Same, but higher gas temp.	480	....	10^{8}
Clay catalyst dust (no conditioning)	350	25.0	5×10^{11}
Same, but conditioned with NH_3, 1 part per 50,000 parts of gas	350	25.0	1×10^{10}

Acknowledgment

The author wishes to acknowledge the invaluable aid of his colleagues H. J. Hall, R. Brown, and P. Cooperman in the preparation of this paper. They not only conducted much of the experimental work, but also aided in its interpretation and organization.

Notation

- ρ = resistivity
- A = constant characteristic of material
- E = activation energy of electrons, or energy required to raise bound electrons to the conduction band, typically of the order of 1 electron-volt
- T = absolute temperature
- k = Boltzmann constant

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Presented at A.I.Ch.E. meeting, Los Angeles, Calif.

The Koppers-Hasche reformer utilizes specially fabricated tiles in masses opposing one another and separated by the combustion zone. A demonstration unit operated at Koppers' Verona laboratories has shown high yields of ethylene and acetylene from propane and other feed stocks which may be accommodated without changes in equipment—only in operating conditions.

Hydrocarbon reforming by A NEW PYROLYTIC PROCESS

G. L. Fleming
Koppers Company, Inc.
Pittsburgh, Pennsylvania

All processes for reforming hydrocarbons consist essentially of two elements: (1) a source of heat, and (2) a means of transferring this heat to the hydrocarbon to be reformed. Past developments in this field have utilized two types of equipment to perform this operation: (1) tubular cracking furnaces, and (2) regenerative refractory furnaces of the stationary or moving bed heat carrier type. Characteristic of the latter is the pebble heater. In conventional tubular furnaces, the heat liberated by the combustion of a fuel is transferred through metallic or ceramic tubes confining the hydrocarbon. In pebble heaters the heat liberated by the combustion of the fuel is transferred to the hydrocarbon by mobile ceramic masses. The Koppers-Hasche process, relatively new in the field of hydrocarbon reforming, stores the heat liberated by the combustion of the fuel in an efficient regenerative tile mass.

Construction of Reformer

The construction of the Koppers-Hasche reformer is illustrated in the accompanying cut-away view of a unit in use for reforming hydrocarbons by the partial oxidation method. (Figure 1.)

The reformer consists essentially of two parallel masses of tile (*1*), numbers 6 and 8 joined at one end by a combustion zone, number 7, and separated by a wall of firebrick. The tile masses and the combustion zone are surrounded by a layer of firebrick and a layer of insulating brick to minimize radiation heat losses. An external steel shell encloses the ceramic materials and adds rigidity to the structure.

The tiles, designed as a heat transfer medium, are the heart of the process and are specially fabricated from high purity alumina to withstand severe thermal shock and operating temperatures in excess of 3,000° F.

Each tile is 9 in. long, 9 in. wide and ⅝ in. thick. Both faces of the tile are fabricated with half-channels ⅜-in. diam. on ¾-in. centers. The tiles, when laid face to face, without bonding material, form the regenerative tile masses shown in Figure 2. The half-channels match to form a multiplicity of small parallel flues extending throughout the length of the regenerative mass.

The flues are equidistant from one another and the relationship between the surface area of the flue and the surrounding ceramic mass is such that a maximum rate of heat transfer is obtained. One cu.ft. of assembled tile contains approximately 30 sq.ft. of flue surface area.

The regenerative tile mass just described is utilized in all Koppers-Hasche reformers. The length and the cross section of the tile masses will vary to fit the needs of a particular application. The relationship of the masses with respect to one another may change, but all masses are formed in this way. The auxiliaries or external controls, such as reversing valves, mixing equipment,

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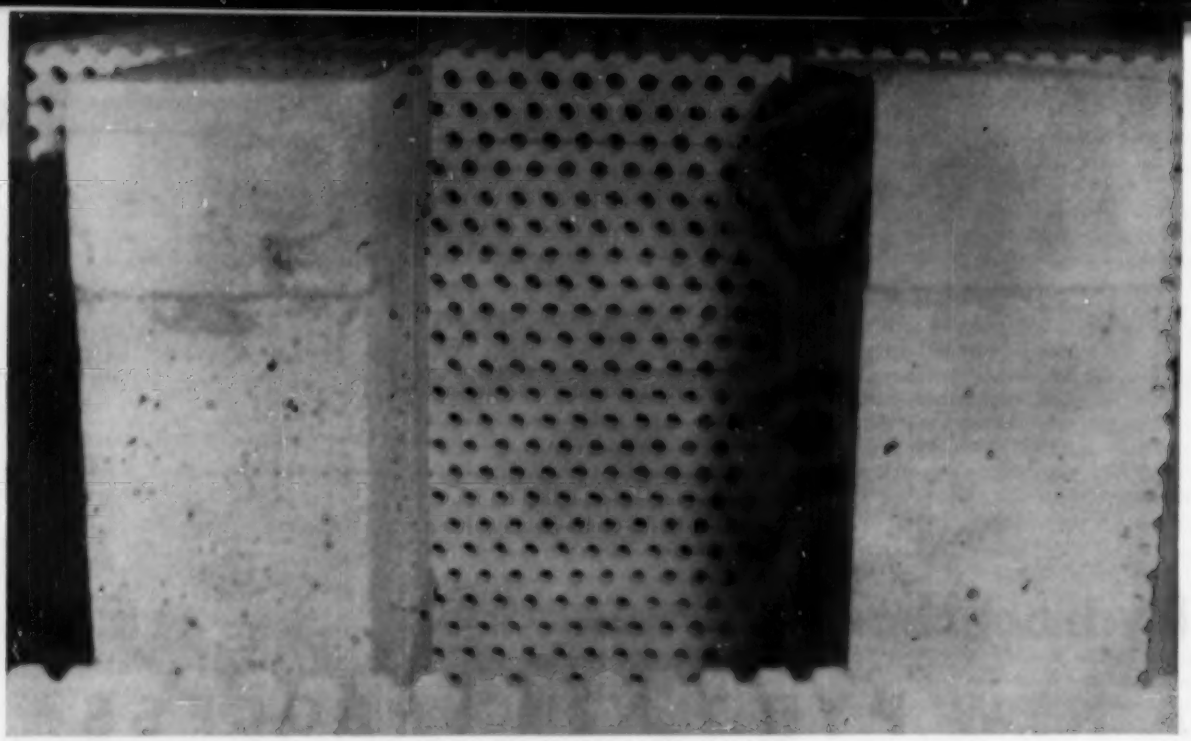


Fig. 2. Photograph of an assembled tile mass shows matched half-channels which form small parallel flues.

blowers, and controls will also vary to suit the individual needs of the specific operation.

Operation of the Reformer—Partial Oxidation Method

The partial oxidation method of reforming is used primarily for the production of heating gases from propane, butane, or natural gasoline (Figure 1).

To place the reformer in operation, the combustion zone and tile masses are heated initially to approximately the operating temperature by heating-up burners inserted in the combustion zone. After the tiles have reached the proper temperature, the burners are removed and the heating-up ports closed. No further external heat is supplied to the process.

Again, with reference to Figure 1, the liquid hydrocarbon to be reformed is transferred by pump (1) from storage (2) to the vaporizer (3) where the hydrocarbon liquid is vaporized. The pressure of the vapors is controlled so that the vapors enter the Venturi injector (4) at approximately 30 lb./sq.in. gauge. The vapors in passing through the Venturi injector inspirate a predetermined amount of air. The resulting air-gas mixture is noninflammable at atmospheric conditions. This mixture then flows through the four-way reversing valve (5) into one of the regenerative tile masses (6).

In passing through the tile mass, the air-gas mixture is preheated to the autoignition temperature. As the mixture reaches the autoignition temperature, a portion of the hydrocarbon vapors burns. The heat thus liberated maintains the proper cracking temperature in the reformer.

After passing through the combustion zone (7) the gases enter the second regenerative tile mass (8), where the greater portion of their sensible heat is extracted and stored for the following cycle. The partially cooled gases leave the reformer through the four-way reversing valve (5) and are sent to the gas cooler (9) for final cooling before distribution.

At regular intervals, the direction of flow through the reformer is reversed so that the gases enter through tile mass (8) and leave through tile mass (6). The reversal of flow thus utilizes the heat stored in the regenerative tile mass during the previous cycle and maintains a balance of heat throughout the reformer.

In the partial oxidation process there is only one variable—namely, the amount of air inspirated by the hydrocarbon vapor in passing through the Venturi injector. An air-gas mixture containing approximately one part air and one part propane vapor will produce a reformed gas with a heat content of approximately 1,000 B.t.u./cu.ft., while an air-gas mixture containing approxi-

Table 1.—Reformed Propane Analysis

	Partial Oxidation					
Heating value B.t.u./cu.ft.	590	680	785	890	991	1,091
Make-gas composition, vol. %						
CO_2	2.1	2.0	1.4	1.0	0.7	0.7
C_nH_n	0.7	0.3	0.2	0.2	0.2	0.2
C_3+	2.2	4.0	6.1	7.4	7.6	7.5
C_nH_n	12.8	12.9	12.6	12.1	11.5	10.7
O_2	1.8	1.7	1.7	1.7	1.7	1.7
CO	6.0	5.0	4.4	3.9	3.6	3.3
H_2	8.7	7.1	6.4	5.9	5.5	5.2
CH_4	12.3	12.5	12.2	11.7	11.0	10.2
C_nH_n	5.9	8.2	11.0	14.5	19.2	24.2
N_2	47.5	46.3	44.0	41.6	39.0	36.3
Sp. gr. (air = 1.0)	0.89	0.93	0.97	1.01	1.04	1.07
Air-propane ratio feed	2.3	1.9	1.6	1.4	1.2	1.1
Avg. combustion zone temp., ° F.	1,550	1,490	1,430	1,370	1,310	1,250
Cold gas efficiency, %	92	93	94	95	96	96.7

mately two and one-half parts air, and one part propane vapor, will produce a reformed gas with a heat content of approximately 600 B.t.u./cu.ft.

Table 1 illustrates the typical analysis of the reformed propane at various heating values from approximately 600 B.t.u./cu.ft. to approximately 1,100 B.t.u./cu.ft. at intervals of 100 B.t.u.

As would be expected, the percentage of unreformed propane decreases at the lower heating values and the percentages of hydrogen and the lighter hydrocarbons (methane, ethylene, etc.) increase appreciably. The air-gas ratios of the feed mixture and the average combustion-zone temperature for the various mixtures are shown. The higher air-gas ratios result in a higher combustion-zone temperature and, therefore, deeper cracking of the propane is effected.

The heat requirements of the reformer are composed of the following: (a) heat required for cracking the hydrocarbon, (b) sensible-heat loss due to the temperature differential between the incoming and exit gases, and (c) radiation loss from the shell of the reformer. The sensible heat loss and the radiation loss, (b) and (c), amount to approximately 1 to 2% of the total energy input.

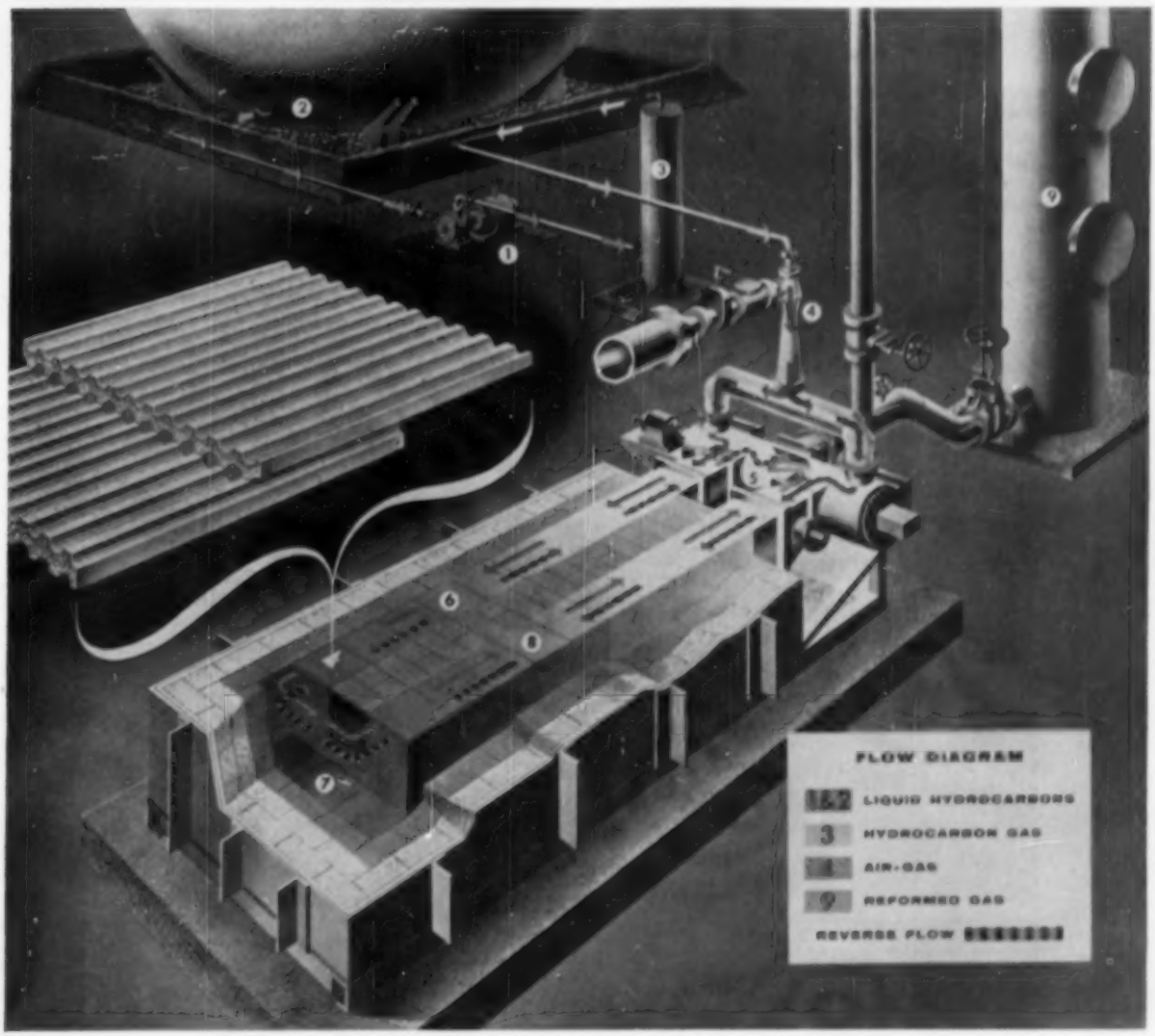
Actual cold gas efficiencies correlating the heat content of the liquid feed to the heat content of the reformed gas are exceptionally high and vary from approximately 92% when reforming to a 600 B.t.u./cu.ft. gas to approximately 96.5% when reforming to a 1,100 B.t.u./cu.ft. gas.

Hydrocarbon reforming by partial oxidation in this reformer has found acceptance in the gas industry for the production of base-load and peak-load heating gases. Presently there are twenty-seven such installations operating in public utilities, with a combined daily send-out capacity of more than 35 million cubic feet of reformed gas.

The acceptance of this reformer is due primarily to the interchangeability of the reformed gases, and their ability to burn in burners adjusted for other gases; thus, costly appliance conversions and customer complaints are eliminated. For example, actual operating data have shown that reformed propane with a heating value between 600 and 630 B.t.u./cu.ft. is interchangeable with carburated water gas with heating values ranging from 525 to 570 B.t.u./cu.ft.

The change-over from carburated

Fig. 1. Cut-away drawing showing flow through the Koppers-Hasche reformer.



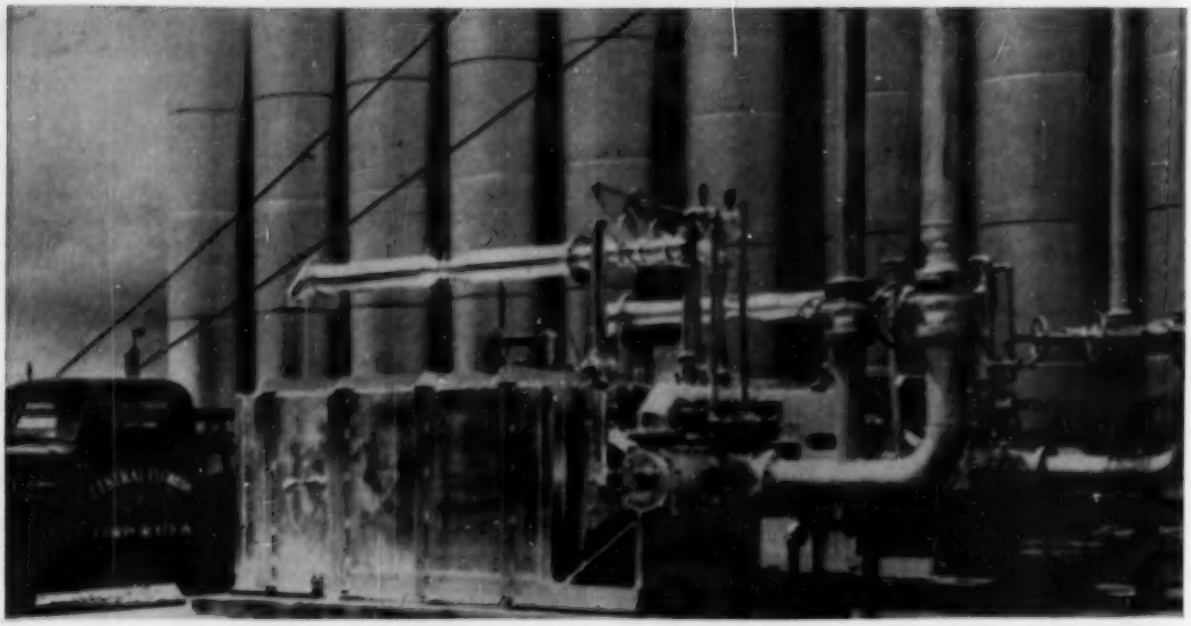


Fig. 3. Two reformers used for the production of a base-load gas from propane.

water gas to reformed liquefied petroleum gas in twenty-four of the twenty-seven installed reformers was made without costly appliance conversions, and a general decrease in customer complaints has been noted since the reformers have been placed in production. All installations have shown savings in production costs because of the lower raw material and manpower requirements.

However, in this age of natural gas there are only a few utilities which do not have natural gas available for distribution. Here the reformer is also versatile to the extent that reformed gases with heat contents ranging from 1,050 B.t.u./cu.ft. to 1,250 B.t.u./cu.ft. are interchangeable with most of the natural gases distributed today.

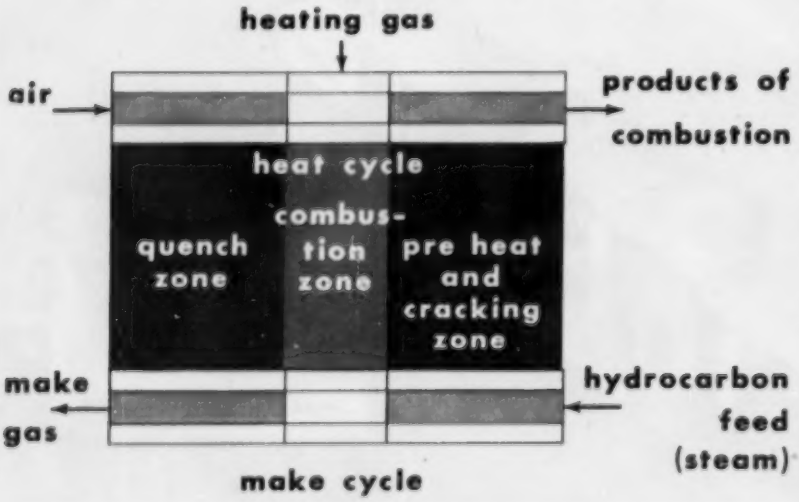
All gas utilities are faced with the problem of meeting peak demands in the winter months. If a contract is made for sufficient natural gas to meet all winter demands, then the basic rate for the entire year is increased and the cost of the natural gas to the consumer becomes less attractive, if not prohibitive. Naturally, the best method of meeting such peak loads is to store the natural gas in underground domes during off-peak periods. Satisfactory storage facilities, however, are seldom available in the desired location.

Actual operations of three Koppers-Hasche reformers at two different locations have shown that the reformed gases, produced from the liquefied petroleum gases and natural gasoline, are interchangeable with the natural gas being distributed. The production costs per cubic foot of send-out gas are low due to (a) the high thermal efficiency of the reformer, (b) the low-heat content of the interchangeable send-out gas, and (c) the reformer's ability to utilize a low cost feedstock.

Figure 3 shows two reformers used for the production of a base-load gas from propane. Each reformer has a capacity of one million cubic feet a day of 656 B.t.u./cu.ft. reformed propane. By the standards of conventional gas producing equipment they are exceedingly small in size. This figure shows also a portion of the vertical storage tanks used for pressurized storage of the reformed gas at 75 lb./sq.in. gauge prior to distribution. The reformed gas from this plant is distributed to neighboring communities 18 miles distant.

Figure 4 shows a recent reformer installation for the production of a peak-load gas interchangeable with natural gas from propane, butane, or natural gasoline. This reformer has a capacity of two and one-half million cubic feet a day of send-out gas. Actual distribution tests have shown the reformed gases to be interchangeable with the natural gas presently distributed.

Fig. 5. Schematic flow diagram of the reformer in cyclic operation.



Cyclic Operation

When a reformed gas stream with a low-inert content is desired, the reformer is adapted to cyclic operation.

Figure 5 illustrates schematically the flows through a cyclic Koppers-Hasche reformer, the basic construction of which does not differ appreciably from the unit just described. The main difference lies in the fact that the tile masses are opposing one another with the combustion zone separating them. As in the partial oxidation process, the two regenerative tile masses are surrounded by a layer of firebrick and insulation, and encased in a steel shell. To illustrate the operation, two units are shown: (1) heat portion of the cycle, and (2) the make portion of the cycle.

For initial start-up, heating fuel (either gaseous or liquid hydrocarbons) is introduced into the combustion zone and ignited. Air required for combustion of the heating gases is supplied by an air blower and introduced through the quench zone. The air and heating gas burn in the combustion zone and pass through the preheat and cracking zone where their sensible heat is extracted.

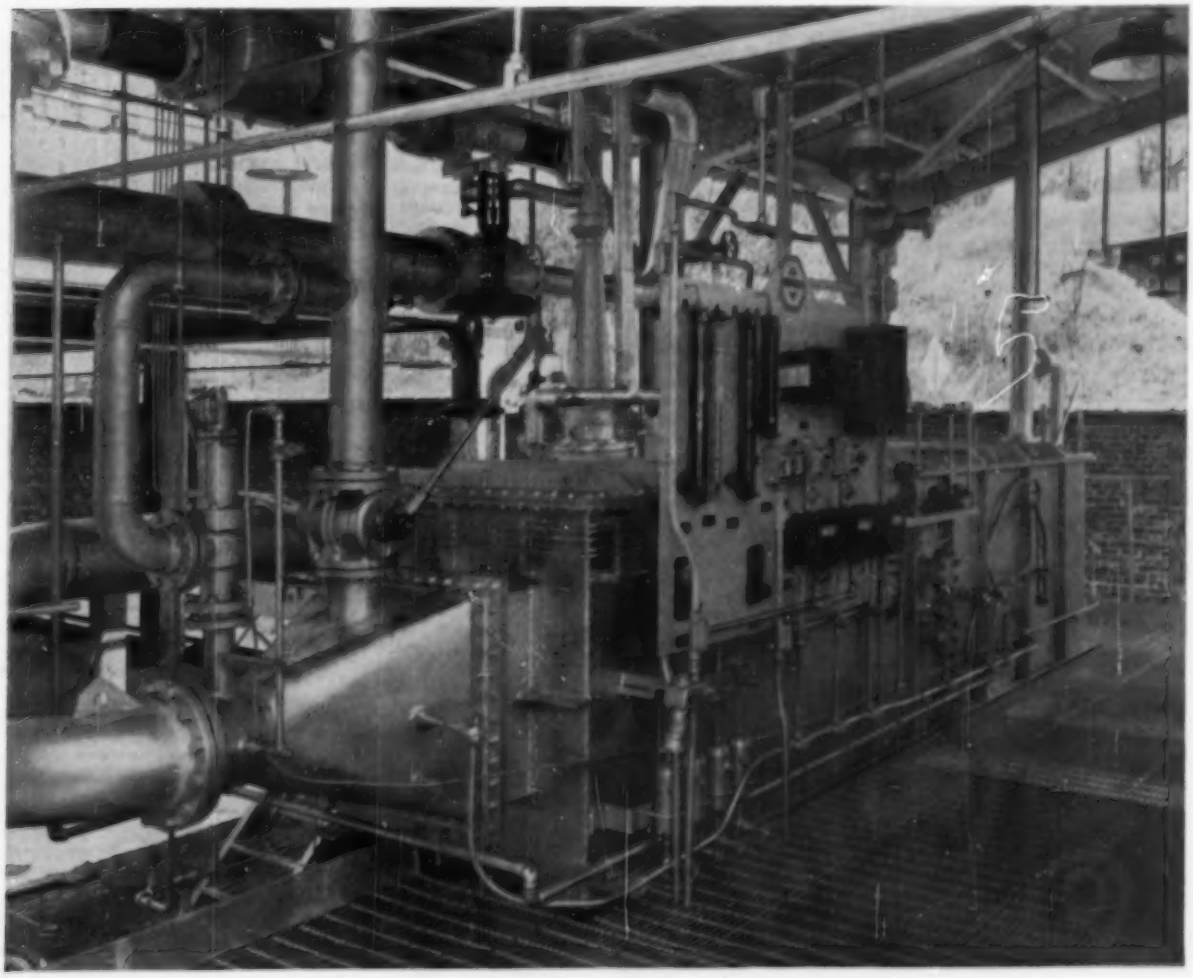
When the combustion zone and preheat and cracking zone have been brought up to operating temperature—between 1,600 and 2,650° F.—the heating gases and air are turned off. A short steam purge clears the tile mass of unburned hydrocarbons, oxygen, nitrogen, and products of combustion. The gas to be reformed then enters the reformer in the reverse direction through the preheat and cracking zone. The gases, when passing through this zone, are gradually preheated to their cracking temperature and are reformed to the desired products.

After passing through the combustion zone the reformed gases enter the quench mass where they are rapidly cooled and further reactions are stopped. Then, after a make cycle, the heating gas and quench air are again introduced to maintain the desired operating temperatures throughout the reformer. Under normal conditions the reformer is operated on a total cycle of 2 min.—1 min. for heating and purging, and 1 min. for reforming. A temperature swing of approximately 100° F. is permissible in the combustion zone.

The temperature of the quench mass is readily controlled by the volume of air passing through it during the heat portion of the cycle. It can be seen easily from the foregoing that the controllable variables in the process are many.

Aside from the choice of feedstocks, it is possible to vary (1) amount of steam introduced with the feedstock,

Fig. 4. This Koppers-Hasche reformer installation has a capacity of 2.5 million cu.ft./day of send-out gas.



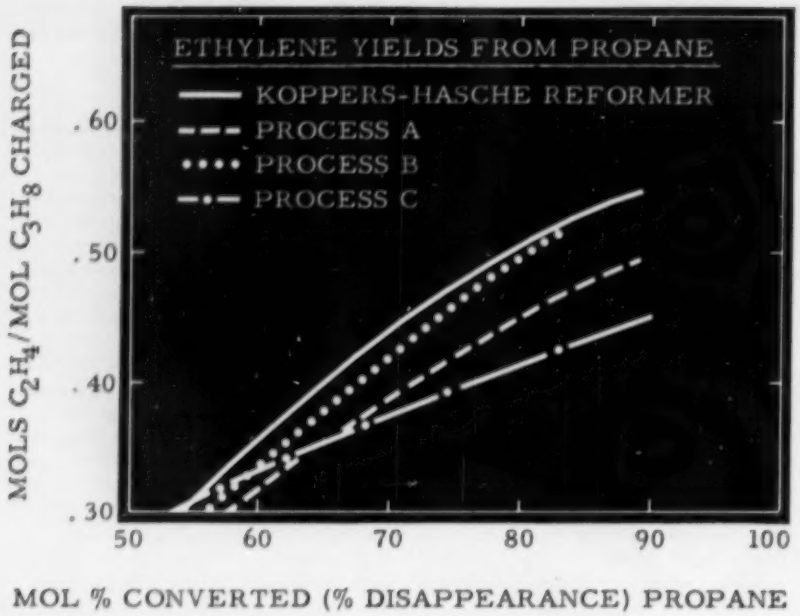


Fig. 6. Ethylene yields from propane in various processes.

(2) pressure of the reactants, (3) temperature of the reaction zone, (4) length of the reaction zone, (5) temperature of the quench zone, and (6) length of the cycle, and subsequently the temperature variation in the tile mass during the cycle.

An experimental reformer was installed at the Verona Research Laboratories of the Koppers Company, Inc., and an extensive experimental program was undertaken to determine the operating results of this unit. During these experimental runs, a variety of feedstocks was used to determine the optimum conditions required for the production of acetylene and ethylene from various feedstocks.

A summary of the representative results of this experimental program are shown in Table 2. The temperatures shown in this table are the control temperatures in the combustion zone during the operation.

Steam jet ejectors were used to reduce the pressure of the reactants within the reformer; lower absolute pressures were found beneficial to high conversion of natural gas and propane to acetylene.

The make-gas composition was determined by Podbielniak analysis of the composite samples taken during extended periods of operation and, therefore, represent the average composition of the make gases. The residual nitrogen found in the make gases is caused by the "breathing" of the brickwork surrounding the tile mass. As the relationship between the cross-sectional area of the tile masses and the cross-sectional area of the insulating refractories is increased, the residual nitrogen found in the make gases will be further reduced.

The conversion and yields shown here have been calculated from the preceding analysis. In all cases, the yields of the desired products are high; 20 wt. % of the natural gas to the reformer was converted to acetylene. Also, 34 wt. % of the propane feed was converted to ethylene. By varying the operating conditions of the reformer, 32.6 wt. % of the propane feed was converted to ethylene and 16.1 wt. % was converted to acetylene. A further change in the operating conditions resulted in 13.4 wt. % of the propane being converted to ethylene and 28.3 wt. % to acetylene. These results are indicative of the versatility of the reforming unit. No modification of equipment was made; only the operating conditions were varied to obtain this wide range of results.

The yields for both the regenerative-type furnace and cracking reformer are based on a once-through basis. It is obvious that if recycling the tail gas is economic, it may be carried out on either tubular- or regenerative-type furnaces.

Several investigators have previously published data showing the yields of ethylene from propane that have been obtained from various processes. These are shown in Figure 6. The yields of ethylene are expressed as moles of ethylene produced per mole of propane feed plotted against the per cent conversion of propane. Results obtained in the Koppers-Hasche reformer, as shown by the solid line, indicate slightly greater yields of the ethylene than those obtained by other processes. The conversion of propane to ethylene has been chosen for this comparison because of the availability of published data. Yields of acetylene and ethylene from other feedstocks have been found to compare favorably with published results.

A comparison of the cyclic reformer and other reforming furnaces shows the following:

1. Yields of the desired products are similar.
2. The efficiency of the Koppers-Hasche reformer is high and no waste heat recovery system is required. The make gases leave at 300 to 450° F.
3. Two Koppers-Hasche reformers are required for continuous production.

Table 2.—Operating Data and Results for Representative Runs (Cyclic)

Feed gas ..... Desired product (s)	Nat. Gas acetylene	Propane ethylene	Propane ethylene (+ acetylene)	Propane (acetylene + ethylene)	Ethane ethylene
Temperature, ° F.	2,440	1,850	2,265	2,450	1,750
Pressure, lb./sq.in. abs.	10	15	15	9	15
Steam, mole/mole feed	2.2	0.0	4.4	6.2	0.0
Make-gas composition, vol. % ...					
CO_2	2.5	0.3	1.4	2.0	0.5
CO	9.1	0.3	3.6	6.8	0.3
H_2	57.2	25.8	40.0	44.8	42.5
N_2	5.9	1.8	2.3	11.5	1.4
CH_4	18.9	30.6	26.0	15.6	10.8
C_2H_6	....	1.9	....	....	8.9
C_2H_4	0.8	25.6	16.8	5.2	30.0
C_2H_2	5.4	1.7	8.9	11.7	2.6
C_3H_8	....	5.8	....	....	....
C_3H_6	....	4.2	....	....	....
C_3+	0.2	....	....	0.9	3.0
C_4+	....	1.1	1.0	1.5	....
C_5+	....	0.9	....	....	....
Conversion, %	57.2	87.8	99–100	98–100	83.9
Yields, wt. % of feed					
C_2H_6	....	34.3	32.6	13.4	50.7
C_2H_2	20.0	2.1	16.1	28.3	4.1
C_3H_8	....	8.4	....	....	....

Several investigators have previously published data showing the yields of ethylene from propane that have been obtained from various processes. These are shown in Figure 6. The yields of ethylene are expressed as moles of ethylene produced per mole of propane feed plotted against the per cent conversion of propane. Results obtained in the Koppers-Hasche reformer, as shown by the solid line, indicate slightly greater yields of the ethylene than those obtained by other processes. The conversion of propane to ethylene has been chosen for this comparison because of the availability of published data. Yields of acetylene and ethylene from other feedstocks have been found to compare favorably with published results.

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NEW STANDARD LETTER SYMBOLS For Chemical Engineering

*Mott Souders, Jr.**

Chairman, Subcommittee 12,
A.S.A. Sectional Committee Y 10 on Letter Symbols

The letter symbols for the concepts most widely used in chemical engineering are listed on the following pages.

A letter symbol is a single letter used to represent a primary concept for a physical quantity, and it may be used together with modifying subscript or superscript. A subscript may designate a place in space or time, a system of units, or a constant or reference value. A superscript may designate a dimensionless form, a reference or equilibrium value, a sequence in time or space, or a mathematical identification (average value, derivative, tensor index).

This list, the official one of the A.I.Ch.E., has been adopted by the American Standards Association as American Standard ASA Y10.12-1955. The new compilation of standard symbols, a revision of the earlier standard (*3*), was prepared by a committee of chemical engineers in consultation with similar committees in other fields of engineering and with many individuals concerned with chemical engineering literature, such as editors, publishers, teachers, and authors.

History

Letter symbols have been a concern of the A.S.A. since 1926, when it established the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering. This committee, designated as A.S.A. Sectional Committee Y10, consists of representatives from forty-two professional societies, technical associations, and government departments. The A.S.M.E. sponsors the printing and distribution of all American Standards for Letter Symbols, copies of which are obtainable from the office of the Standards Administrator, 29 W. 39th Street, New York 18, New York.

The development of an official list of uniform symbols for chemical engineering began in 1932 with the establishment of an A.I.Ch.E. committee to investigate the subject and to recommend usage. This committee published a tentative list of symbols in 1938 (*1*) and a revised list in 1944 (*2*). In July of 1943 A.S.A. Sectional Committee Y10 appointed Subcommittee 12 for Chemical Engineering with J. H. Perry as chairman and membership identical with that of the A.I.Ch.E. Committee on Symbols and Nomenclature. As a result of the work of this committee the first standard symbols for chemical engineering were approved by A.S.A. in September, 1946. Subcommittee 12 was reconstituted, and it submitted a draft proposal for the revisions of the earlier standard in 1952. A series of revisions of this proposal resulted in one that was approved by the Sectional Committee on March 31, 1954, and adopted by the A.S.A. on October 28, 1955.

Organization of the New Standard

A new plan has been used in the arrangement of symbols and concepts. Instead of the former plan of grouping the symbols by unit operations, a more fundamental organization has been achieved by listing the symbols under categories which are basic to all operations and processes. It is believed that this arrangement not only serves better in defining the use of the symbols and in locating the concept, but also emphasizes the common significance of the concept whatever the operation or process. The fundamental categories used are:

1. General concepts
2. Geometrical concepts
3. Intensive properties
4. Symbols for concentrations
5. Symbols for rate concepts
6. Dimensionless numbers
7. Modifying signs for principal symbols

It is hoped that this system of fundamental classification will encourage authors to use the same standard symbol regardless of the field of specialization. For example, an author needing a rate symbol for quantity per unit time, unit area can find a standard symbol under this classification whether his field is heat transfer, filtration, or extraction.

A few symbols have been dropped from the old standard because they do not conform to current usage, and many of the old symbols have been more clearly defined. A number of new concepts have been added, some from other fields of science and engineering and some primarily for chemical engineering. New listings of especial interest include symbols for the eddy transport of mass, momentum, and heat; symbols for volumetric space velocity and moles reacted per unit time, unit reactor volume; a symbol for the relative distribution of two components between successive stages; and a new dimensionless group, the Sherwood number.

The units used to illustrate the symbols and the abbreviations of them are recommendations of the A.I.Ch.E. but do not constitute a part of the American Standard. The A.S.A. requires that periods not be used in abbreviations, but the editorial policies of both the A.I.Ch.E. and the A.C.S. require the use of a period after each word abbreviated. In the publications of these societies, periods are inserted after abbreviations for the guidance of the reader. They avoid ambiguity and enable the reader to tell at a glance that a group of letters is an abbreviation rather than a symbol or a word. Omission of periods is an aid to the printer, but inclusion of periods is an aid to the reader.

* Other members of Subcommittee 12 were T. B. Drew, J. C. Elgin, C. E. Lapple, W. H. McAdams, D. O. Myatt, J. H. Perry, F. D. Rossini, and J. H. Rushton.

In the preparation of the new list of symbols an attempt has been made to follow the general rules widely used in American Standards.

One of these rules requires that symbols be easily identified, whether printed, typewritten, or handwritten. Examples of letters to be avoided are lower case English o and l, which are confused with zero and unity, and most of the Greek capitals, which are indistinguishable from English capitals. In order to extend the choice of symbols, Old German, Hebrew, Arabic, and other alphabets have been proposed, but these have been discarded because they are not widely enough known to be easily recognizable.

Another rule is that symbols should be clear in reference. The same letter should never stand for two different concepts in the same context or equation, and duplication of meanings should be avoided wherever possible. Since the limited number of characters available in the English and Greek alphabets makes multiple meanings inevitable, alternate symbols have been listed in many cases so that authors may choose an unambiguous set. In the cases of some of the most confusing symbols in engineering, certain conventions are gradually becoming established, such as always using P for power, p for pressure, T for temperature, t for time. Although chemical engineers have not followed these conventions with any unanimity, they are urged to do so. In any case, alternate symbols for these concepts have been provided except for power, which in accordance with international custom is always P.

As a further aid to clarity in reference, the overworked symbol H can be rested by using (with suitable subscripts) the general symbol Y for mole ratios as an alternate for humidity quantities. The symbols v and V indiscriminately used for volumes and velocities produce confusion. For clarity, u is recommended for velocity in general and V for volume in general, with $\bar{V}$ or preferably V' limited to volumetric average velocity and v used for lateral component of local velocity. The symbol v for specific volume has been retained, but it is hoped that it will usually be replaced by its equivalent, reciprocal density, $1/\rho$.

Another rule for letter symbols requires that the same primary symbol should be used throughout for the same generic physical quantity regardless of the units used or of special values occurring at different states, points, parts, or times. For example, the letter H should always be used for enthalpy rather than H when the units are moles and h when the units are pounds. Although highly specialized notation has not been standardized, the unnecessary introduction of new primary symbols is to be avoided. Within a narrow specialty or in a developing field where an author may need more specific symbols than are given in a standard list, he should select his additional symbols to avoid conflict with other closely related fields, making use as far as possible of standard superscripts and subscripts. By all means he should resist the temptation to oversimplify his own problem of notation at the expense of confusion to everyone else.

Compromises are needed to arrive at any standard system of notation. Each member of the committee found it necessary to yield some of his lifelong habits in the use of symbols. Every user of the standard will probably have a similar experience. The general good of uniform notation is the real goal, and this goal will be attained only in proportion to the use that each chemical engineer makes of the standard proposed.

In about five years it will be time to begin another revision of the standard. Meanwhile any chemical engineer is invited to become an unofficial member of the committee by offering his comments, criticisms, or suggestions.

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Letter Symbols for Chemical Engineering

LETTER SYMBOLS FOR PRINCIPAL CONCEPTS

Listing is alphabetical by concept within each category. Illustrative units or definitions are supplied where appropriate.

	Symbol	Unit or definition
1. General Concepts		
Acceleration	a	(ft./sec.)/sec.
Of gravity	g	(ft./sec.)/sec.
Base of natural logarithms	e	
Coefficient	C	
Difference, finite	Δ	
Differential operator	d	
Partial	∂	
Efficiency	η	
Energy, dimension of	E	B.t.u., (ft.)(lb. force),
Enthalpy	H	B.t.u.
Entropy	S	B.t.u./°R.
Force	F	lb. force
Function	ϕ, ψ, χ	
Gas constant, universal	R	To distinguish, use R_0
Gibbs free energy	G,F	$G = H - TS$, B.t.u.
Heat	Q	B.t.u.
Helmholtz free energy	A	$A = U - TS$, B.t.u.
Internal energy	U	B.t.u.
Mass, dimension of	m	lb.
Mechanical equivalent of heat	J	(ft.)(lb. force)/B.t.u.
Moment of inertia	I	$(ft.)^4$
Newton law of motion, conversion factor in	g_c	$g_c = ma/F$, (lb.)(ft.)/(sec.)^2(lb. force)
Number		
In general	N	
Of moles	n	
Pressure	p	lb. force/sq. ft.; atm.
Quantity, in general	Q	
Ratio, in general	R	
Resistance	R	
Shear stress	τ	lb. force/sq. ft.
Temperature		
Dimension of	θ	
Absolute	T	°K. (Kelvin); °R. (Rankine)
In general	T, t	°C.; °F.
Temperature difference, logarithmic mean	$\bar{\theta}$	°F.
Time		
Dimension of	T	sec.
In general	t, τ	sec.; hr.
Work	W	B.t.u.

2. Geometrical Concepts

	Symbol	Unit or definition
Linear dimension		
Breadth	b	ft.
Diameter	D	ft.
Distance along path	s, x	ft.
Height above datum plane	Z	ft.
Height equivalent	H	ft. Use subscript p for equilibrium stage and t for transfer unit
Hydraulic radius	r_H	ft.; sq. ft./ft.
Lateral distance from datum plane	Y	ft.
Length, distance or dimension of	L	ft.
Longitudinal distance from datum plane	X	ft.
Mean free path	λ	cm.; ft.
Radius	r	ft.
Thickness		
In general	B	ft.
Of film	B_f	ft.
Wave length	λ	cm.; ft.
Area		
In general	A	sq. ft.
Cross section	S	sq. ft.
Fraction free cross section	ϵ	
Projected	A_p	sq. ft.
Surface		
Per unit mass	A_w, s	sq. ft./lb.
Per unit volume	A_v, a	sq. ft./cu. ft.
Volume		
In general	V	cu. ft.
Fraction voids	ϵ	
Humid volume	v_H	cu. ft./lb. dry air
Angle	α, θ, ϕ	
In x,y plane	α	
In y,z plane	ϕ	
In z,x plane	θ	
Solid angle	ω	
Other		
Particle-shape factor	ϕ_s	

3. Intensive Properties

Absorptivity for radiation	α	
Activity	a	
Activity coefficient, molal basis	γ	
Coefficient of expansion		
Linear	α	(ft./ft.)/°F.
Volumetric	β	(cu. ft./cu. ft.)/°F.
Compressibility factor	z	$z = pV/RT$
Density	ρ	lb./cu. ft.
Diffusivity		
Molecular, volumetric	D_v, δ	cu. ft./(hr.)(ft.); sq. ft./hr.
Thermal	α	$\alpha = k/c\rho$, sq. ft./hr.
Emissivity ratio for radiation	ϵ	
Enthalpy, per mole	H	B.t.u./lb. mole
Entropy, per mole	S	B.t.u./(lb. mole)(°R.)
Fugacity	f	lb. force/sq. ft.; atm.
Gibbs free energy, per mole	G, F	B.t.u./lb. mole
Helmholtz free energy, per mole	A	B.t.u./lb. mole
Humid heat	c_s	B.t.u./(lb. dry air)(°F.)
Internal energy, per mole	U	B.t.u./lb. mole
Latent heat, phase change	λ	B.t.u./lb.
Molecular weight	M	lb.
Reflectivity for radiation	ρ	
Specific heat	c	B.t.u./(lb.)(°F.)
At constant pressure	c_p	B.t.u./(lb.)(°F.)
At constant volume	c_v	B.t.u./(lb.)(°F.)
Specific heats, ratio of	γ	
Surface tension	σ	lb. force/ft.
Thermal conductivity	k	B.t.u./(hr.)(sq. ft.)(°F./ft.)
Transmissivity of radiation	τ	
Vapor pressure	p^*	lb. force/sq. ft.; atm.
Viscosity		
Absolute or coefficient of	μ	lb./(sec.)(ft.)
Kinematic	ν	sq. ft./sec.
Volume, per mole	V	cu. ft./lb. mole

4. Symbols for Concentrations

Absorption factor	A	$A = L/K^\circ V$
Concentration, mass or moles per unit volume	c	lb./cu. ft.; lb. moles/cu. ft.
Fraction		
Cumulative beyond a given size	ϕ	
By volume	x_v	
By weight	x_w	
Humidity	H, Y_H	lb./lb. dry air
At saturation	H_s, Y^*	lb./lb. dry air
At wet-bulb temperature	H_w, Y_w	lb./lb. dry air
At adiabatic saturation temperature	H_s, Y_s	lb./lb. dry air
Mass concentration of particles	c_p	lb./cu. ft.
Moisture content		
Total water to bone-dry stock	X_T	lb./lb. dry stock
Equilibrium water to bone-dry stock	X^*	lb./lb. dry stock
Free water to bone-dry stock	X	lb./lb. dry stock
Mole or mass fraction		
In heavy or extract phase	x	
In light or raffinate phase	y	
Mole or mass ratio		
In heavy or extract phase	X	
In light or raffinate phase	Y	
Number concentration of particles	n_p	number/cu. ft.
Phase equilibrium ratio	K°	$K^\circ = y^*/x$
Relative distribution of two components		
Between two phases in in equilibrium	α	$\alpha = K_i^\circ/K_j^\circ$
Between successive stages	β	$\beta_n = (y_i/y_j)_n/(x_i/x_j)_{n+1}$
Relative humidity	H_R, R_H	
Slope of equilibrium curve	m	$m = dy^*/dx$
Stripping factor	S	$S = K^\circ V/L$

5. Symbols for Rate Concepts

	Symbol	Unit or definition
Quantity per unit time, in general	q	
Angular velocity	ω	
Feed rate	F	lb./hr.; lb. moles/hr.
Frequency	f, N_f	
Friction velocity	u^*	$u^* = (g_c \tau_w \rho)^{1/2}$, ft./sec.
Heat transfer rate	q	B.t.u./hr.
Heavy or extract phase rate	L	lb./hr.; lb. moles/hr.
Heavy or extract product rate	B	lb./hr.; lb. moles/hr.
Light or raffinate phase rate	V	lb./hr.; lb. moles/hr.
Light or raffinate product rate	D	lb./hr.; lb. moles/hr.
Mass rate of flow	w	lb./sec.; lb./hr.
Molal rate of transfer	N	lb. moles/hr.
Power	P	(ft.)(lb. force)/sec.
Revolutions per unit time	n	
Velocity		
In general	u	ft./sec.
Instantaneous, local		
Longitudinal (x) component of	u	ft./sec.
Lateral (y) component of	v	ft./sec.
Normal (z) component of	w	ft./sec.
Volumetric rate of flow	q	cu. ft./sec.; cu. ft./hr.
Quantity per unit time, unit area		
Emissive power, total	W	B.t.u./(hr.)(sq. ft.)
Mass velocity, average	G	$G = w/S$, lb./(sec.)(sq. ft.)
Vapor or light phase	$G, \hat{G}$	lb./(hr.)(sq. ft.)
Liquid or heavy phase	$L, \bar{L}$	lb./(hr.)(sq. ft.)
Radiation, intensity of	I	B.t.u./(hr.)(sq. ft.)
Velocity		
Nominal, basis total cross section of packed vessel	v_s	ft./sec.
Volumetric average	$\bar{V}, \hat{V}$	(cu. ft./sec.)/sq. ft.; ft./sec.
Quantity per unit time, unit volume		
Quantity reacted per unit time, reactor volume	N_R	(moles/sec.)/cu. ft.
Space velocity, volumetric	A	(cu. ft./sec.)/cu. ft.
Quantity per unit time, unit area, unit driving force, in general	k	
Eddy diffusivity	δ_E	sq. ft./hr.
Eddy viscosity	ν_E	sq. ft./hr.
Eddy thermal diffusivity	α_E	sq. ft./hr.
Heat transfer coefficient		
Individual	h	B.t.u./(hr.)(sq. ft.)(°F.)
Over-all	U	B.t.u./(hr.)(sq. ft.)(°F.)
Mass transfer coefficient		
Individual	k	lb. moles/(hr.)(sq. ft.)(driving force)
Gas film	k_G	To define driving force, use subscript: c for lb. moles/cu. ft., p for atm., x for mole fraction
Liquid film	k_L	
Over-all	K	
Gas film basis	K_G	
Liquid film basis	K_L	
Stefan-Boltzmann constant	σ	0.173×10^{-8} B.t.u./(hr.)(sq. ft.)(°R.)^4

6. Dimensionless Numbers Used in Chemical Engineering

Condensation number	N_{Co}	$\frac{h}{k}\left(\frac{\nu^2}{a}\right)^{1/3}$; $\frac{h}{k}\left(\frac{\nu^2}{g}\right)^{1/3}$
Euler number	N_{Eu}	$\frac{g_c p}{\rho u^2}$; $\frac{g_c \rho p}{G^2}$
Fanning friction factor	f	$\frac{g_c \rho D(\Delta p_f)}{2G^2(\Delta L)}$
Fourier number	N_{Fo}	$\frac{kt}{c\rho L^2}$ or $\frac{\alpha t}{L^2}$
Froude number	N_{Fr}	$\frac{u^2}{aL}$; $\frac{u^2}{gL}$
Graetz number	N_{Gz}	$\frac{cLG}{k}$ or $\frac{L\bar{V}}{\alpha}$
Grashof number	N_{Gr}	$\frac{L^3\rho^2\beta g\Delta t}{\mu^2}$ or $\frac{L^3\beta g\Delta t}{\nu^2}$
Heat transfer factor	j_H	$\frac{h}{cG}\left(\frac{c\mu}{k}\right)^{2/3}$ or $(N_{St})(N_{Pr})^{2/3}$
Lewis number	N_{Le}	$\frac{k}{c\rho D_v}$ or $\frac{\alpha}{D_v}$
Mass transfer factor	j_M	$\frac{k_c}{u}\left(\frac{\mu}{\rho D_v}\right)^{2/3}$
Nusselt number	N_{Nu}	$\frac{hL}{k}$; $\frac{hD}{k}$
Peclet number	N_{Pe}	$\frac{Lu c\rho}{k}$ or $\frac{Lu}{\alpha}$; $\frac{D\bar{V}}{\alpha}$
Prandtl number	N_{Pr}	$\frac{c\mu}{k}$ or $\frac{\nu}{\alpha}$
Prandtl velocity ratio	u^+	$\frac{\bar{u}}{u^*}$
Reynolds number	N_{Re}	$\frac{Lu\rho}{\mu}$; $\frac{DG}{\mu}$
Reynolds number, local	y^+	$\frac{ru^*\rho}{\mu}$
Schmidt number	N_{Sc}	$\frac{\mu}{\rho D_v}$
Sherwood number	N_{Sh}	$\frac{k_c L}{D_v}$ or $j_M(N_{Re})(N_{Sc})^{1/3}$
Stanton number	N_{St}	$\frac{h}{c\rho u}$; $\frac{h}{cG}$
Vapor condensation number	N_{Co}	$\frac{L^3\rho^2 g\lambda}{k\mu\Delta t}$
Weber number	N_{We}	$\frac{Lu^2\rho}{g_c\sigma}$; $\frac{DG^2}{g_c\rho\sigma}$

7. Modifying Signs for Principal Symbols

Concept	Remarks	Superscript	Subscript
Average value	Written over symbol	– (Bar)	
Dimensionless form	Follows symbol	+ (Plus)	
Equilibrium value	Follows symbol	* (Asterisk)	
Fluctuating component	Usually applied to local velocity	′ (Prime)	
Initial or reference value	Follows symbol		0 (zero)
Modified form	Follows symbol	′ (Prime) ″ (Double prime)	
Partial molal quantity	Written over small capitals	– (Bar)	
Sequence in time or space	Follows symbol	′ (Prime) ″ (Double prime)	1, 2, 3, etc.
Standard state	Follows symbol	° (Degree)	
First derivative with respect to time	Written over symbol	. (Dot)	
Second derivative with respect to time	Written over symbol	.. (Double dot)	

ALPHABETICAL INDEX BY SYMBOL

	Primary concept	Subscript concept
a	Acceleration Activity Area, alternate for Surface per unit volume	Acoustic Adiabatic Arithmetic
A	Absorption factor Area Helmholtz free energy	Absolute Area basis Component A
b	Breadth	Baffle Base
B	Heavy-product rate Thickness	Black body Boiling point Component B
c	Concentration, mass or moles per unit volume Specific heat, heat capacity	Concentration basis Contraction Conversion factor Critical Cut-off size
C	Coefficient	Component C
d	Differential operator	Discharge Disperse Drop Dry
D	Diameter Diffusivity Light or raffinate product rate	Component D Distillate
e	Base of natural logarithms	Effective Exit
E	Energy Dimension of In general	Component E Eddy Entrainment
f	Frequency Friction factor, Fanning Fugacity	Film Fluid Frequency Friction
F	Feed rate Force Gibbs free energy	Feed
g	Acceleration of gravity	Gauge Gravity Vapor
G	Gibbs free energy Mass velocity In general Of vapor	Vapor Vapor film basis
h	Individual coefficient of heat transfer	Heat Heated
H	Enthalpy Height equivalent Humidity	Heat basis Humidity Hydraulic
i		Generalized component Interface Internal or inner
I	Intensity of radiation Moment of inertia	
j	Transfer factor	Generalized component
J	Mechanical equivalent of heat	
k	Mass transfer coefficient, individual Quantity per unit time, unit area, unit driving force, in general Thermal conductivity	
K	Mass transfer coefficient, over-all Phase concentration ratio	
L	Heavy or extract phase rate Length Mass velocity of liquid or heavy phase	Liquid Liquid-film basis
m	Mass Dimension of In general Slope of equilibrium curve	Mass Mean
M	Molecular weight	Mass basis Molecular
n	Number concentration Number of moles Revolutions per unit time	Generalized stage number Normal
N	Molal rate Number, in general	

	Primary concept	Subscript concept
a		Initial Outer
O		Over-all
p	Pressure	Constant pressure Particle Plate or stages Pressure basis Projected
P	Power	
q	Quantity per unit time, in general Rate of heat flow Rate of volumetric flow	Rate basis
Q	Heat Quantity, in general	
r	Radius	Radius or radial Reduced
R	Gas constant Ratio, in general Reflux ratio Resistance	Radiation Reactor volume basis Relative value
s	Distance along path Specific surface	Saturation Shape Stress Surface basis
S	Cross section Entropy Stripping factor	Cross-section basis Solid Solvent
t	Temperature Time	Tangential Terminal Transfer unit or units
T	Absolute temperature Temperature, in general	Constant temperature Total
u	Longitudinal component of local velocity Velocity, in general	Upper
U	Heat transfer coefficient, over-all Internal energy	
v	Lateral component of local velocity Nominal velocity Specific volume	Constant volume Velocity basis Volumetric
V	Light or raffinate phase rate Volume, in general Volumetric average velocity	
w	Mass flow rate Normal component of local velocity	Mass basis Wet bulb
W	Work Total emissive power	
x	Distance along path Fraction Mole or mass fraction in heavy or extract phase	Mole fraction basis
X	Longitudinal distance from datum plane Mole or mass ratio in heavy or extract phase	Mole ratio basis
y	Mole or mass fraction in light or raffinate phase	
Y	Humidity Lateral distance from datum plane Mass or mole ratio in light or raffinate phase	
z	Compressibility factor	
Z	Height above datum plane	
α	Absorptivity for radiation Angle Angle in x,y plane Coefficient of linear expansion Relative distribution of two components between two phases at equilibrium Thermal diffusivity	
β	Coefficient of volumetric expansion Relative distribution of two components between successive stages	
γ	Activity coefficient, molal basis Ratio of specific heats	
∂	Differential operator, partial	
δ	Diffusivity, volumetric	Film basis
Δ	Difference, finite	
ϵ	Emissivity ratio for radiation Fraction voids	
η	Efficiency	
θ	Angle Angle in z,x plane Temperature, dimension of	
$\bar{\theta}$	Log mean temperature difference	
λ	Latent heat of phase change Mean free path Wave length	
Λ	Volumetric space velocity	
μ	Viscosity, absolute	At constant viscosity
ν	Viscosity, kinematic	
ρ	Density Reflectivity for radiation	Density basis
σ	Fraction free cross section Stefan-Boltzmann constant Surface tension	
τ	Shear stress Time, alternate for Transmissivity for radiation	
ϕ	Angle Angle in y,z plane Fraction cumulative, larger than a given size Function Particle factor	
ψ	Function	
χ	Function	
ω	Angular frequency Angular velocity Solid angle	

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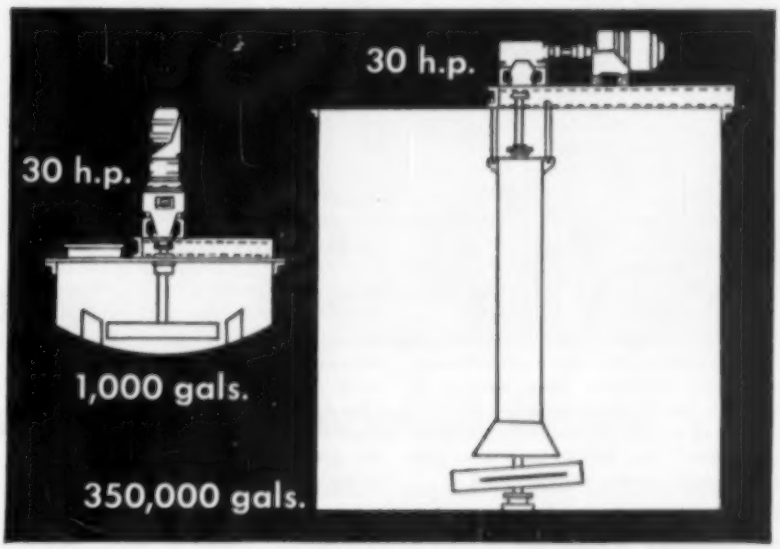

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MONTECATINI ANNOUNCES COMMERCIAL POLY-PROPYLENE

Italian chemical firm claims new process, will license in the U. S.

Representatives of the Montecatini Group of Milan disclosed on June 6 that its company is presently building a plant in Ferrara, Italy, for the production of commercial amounts of polypropylene and that it is engaged in active negotiations for the licensing of its newly developed process in the United States as well as in several European countries.

The announcement was made at a press conference held at the Chemists Club in New York under the joint auspices of the Gordon Research Conferences of the American Association for the Advancement of Science and Chemore Corporation, U. S. representative of Montecatini. Present at the conference were Dr. Piero Giustiniani, Managing Director of the Montecatini Group, and Dr. Giulio Natta of the Milan Polytechnic Institute, who is credited with developing the process.

Natta states that "isotactic" polypropylene produced by the process has a higher melting point than polyethylene, a greater resistance to a variety of solvents, and is well adapted to the production of a high tensile strength fiber. ("Isotactic" was defined as a new type of molecular stereo configuration.)

Key to the process is said to be a radically new catalyst which permits "directed or controlled" polymerization. According to Natta, degree of crystallization, as well as molecular weight, can be predetermined over a wide range, depending on the final properties desired.

Since propylene is, in general, a cheaper raw material than ethylene, the economic significance is obvious.

Natta said further that catalysts of the same type have been used successfully to make a polystyrene and a polybutadiene, both with new and interesting properties, but both still experimental.

Coming at this time, the disclosure constitutes a more or less dramatic turn of events in the plastics race. It has been apparent for some time that extremely important developments have been taking place in the field of polyethylene and certain other related polymers. For example, it was reported in C.E.P. for March, 1956, page 82, that Pullman, under license from Phillips, was expected to enter the low-pressure polyethylene competition and that Pullman's plans were also believed to include the production of polypropylene. It is no secret that several other American companies are in various stages of laboratory and pilot plant work in the same direction. Up to now, however, little detailed information has been made available regarding these processes. This has probably been due, at least in part, to the complicated patent situation.

NATIONAL CARBON EXPANDS ELECTRODE PRODUCTION

Expansion of carbon and graphite electrode production by National Carbon is prompted by continuing growth in use.

The latest phase of a multi-million dollar expansion program that will substantially increase production of carbon and graphite electrodes for the fourth time in five years is underway at National Carbon, a division of Union Carbide. Combined annual capacity of the new facilities will be over 50 million pounds.

Reason is not only industry's ever increasing demand for more quantity, but also industry's need for larger and larger sizes of electrode. In addition, the rapid development of the applications of nuclear energy has resulted in a large demand for fine grain graphite materials.

In the steel industry, prior to 1946, steel production by electric arc furnace was largely limited to alloy, stainless and special purpose steels. Last year the tonnage of plain carbon steel produced by electric arc furnace jumped 55% over 1954, increased its share of the carbon steel market by 23%.

Only a few years ago, 18 inches was the largest diameter graphite electrode made. Today 24 inches is common, and the demand for even larger ones is growing. Ferro-alloys, calcium carbide, and phosphorous production furnaces using electrodes 40 inches in diameter and larger are now coming into use.

At the same time, increasing production of chlorine, magnesium, sodium, chlorates, and manganese dioxide is creating an even greater demand for specifically designed graphite anodes.

TURN FOR MORE NEWS ON

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NEW PLANT, LARGE SCALE EXPANSIONS BOOM AT CYANAMID

Major expansions at Cyanamid's giant Fortier plant near New Orleans, and construction of a 24-million-pound aniline plant, will both be under the supervision of the company's new Engineering and Construction Division.

First phase of Cyanamid's planned expansion at Fortier is a monomethyl styrene plant just completed. Production will start very soon. Final planning is now complete on the next phase, the doubling of production of acrylonitrile. Present facilities will be duplicated and completion date will be 1958. Note: Much new technology is to be incorporated into these facilities.

In the evaluation stage are expansions for the large-scale production of acrylamide. Acrylamide has wide potential industrial use which is still under study.

Cyanamid's Fortier plant which is being expanded for more production of acrylonitrile.

The new acrylonitrile facilities, which will be designed by Chemical Construction Corp., formerly a Cyanamid subsidiary, will include a new oxygen producing unit, a new acetylene unit, and a new hydrogen cyanide unit.

First Fluid Bed Reactor

Already the leading producer of aniline, Cyanamid has begun construction of its new catalytic process aniline plant at Willow Island, W. Va. Rated at an annual capacity of 24 million pounds, completion of construction of the plant is scheduled for the fall of 1957.

The new plant will use for the first time a fluid bed reactor and new catalyst in the manufacture of aniline from nitrobenzene by the reduction process. Units will include nitric acid production, nitric acid concentration, sulphuric acid concentration, acid mixing, hydrogen, nitrobenzene, and aniline.

Design was again done by Chemico, all construction responsibility is in the hands of the new Engineering and Construction Division.

Notable Achievements at JPL

A NEW DISCOVERY... One of the recent achievements at JPL in the field of high temperature materials came as a result of careful X-ray diffraction studies of high purity alloys especially prepared at the Laboratory. A previously unknown compound was discovered in the titanium-aluminum alloy system, probably accounting for the low ductility observed in certain of these alloys.

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To provide the new kinds of materials required for the unusual requirements of rockets, missiles, and nuclear propulsion, the Laboratory is engaged in research on materials suitable for high temperature uses and having high strength with minimum weight. This includes work in metallurgy, ceramics, solid state physics, and chemical thermodynamics.

We are now examining the mechanical behavior of metals and ceramics near their melting points, phase diagrams and properties of alloys, diffusion in solids, kinetics of phase formation, crystal structures, and crystal imperfections. Thermodynamic studies of alloys and of high temperature materials are in progress in relation to phase equilibria and to corrosion resistance.

The work in materials has companion efforts, comparable in scope, related to liquid and solid propellants, and to nuclear propulsion.

Additional openings are available for qualified scientists. If the challenge of new problems in research interests you, please write us outlining your education and experience.

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Corrosion Experience with

A MODERN SALT EVAPORATOR

Corrosion played a major part in determining when the old installation should be abandoned, and was the cause of unexpected trouble in the new installation.

R. B. Richards | International Salt Company, Watkins Glen, New York

Back in 1949 the management of the International Salt Company, following the revelations in a record which had been kept since 1940 on the wall thickness of the evaporator pans in use at its Watkins Glen plant, decided that the entire unit should be replaced. This record indicated that, although the condition was serious only in the first two effects, corrosion was thinning the pan shells to such a point that collapse was possible. It was agreed, therefore, that the new pans should be constructed of a corrosion-resistant metal, hence large welded test pieces were installed in the first-effect pan at the liquid level, insulated from the cast iron body.

At the end of three months the test sections were removed and examined. All 304, 316, 347 stainless steel samples showed minor pitting and roughening of the surface with practically no covering scale. The Monel test piece appeared to be untouched and this was coated with a thin carbonate scale. An independent survey of the metals was made in order to study the steam balance of the plant under present and future conditions. The final decision was to install pans constructed of solid Monel. The design and fabrication of the units was awarded to the Swenson Evaporator Company.

Present-day Design

The first and second effects are 14 ft. diam., 12 ft. high on the straight side with 60-degree cone bottoms and top, fabricated entirely of 7/16 in. Monel plate with suitable external steel reinforcement. The tops are each fitted with a dome which contains a centrifugal separator.

The first-effect heater is comprised of 933 1¼-in. O.D. × 22-ft., 0-in. tubes rolled into 1¼-in. solid Monel tube sheets top and bottom, which provides 6,000 sq. ft. of heating surface measured on the inside diameter.

The tubes are 90/10 cupro nickel and the heater shells are ⅜-in. steel plate. A 24-in. Morris straight flow pump of type 316 stainless steel provides circulation of the brine through 24- and 30-in. diam. monel pipes. The heater, installed vertically directly over the pump discharge, is provided with conical inlet and discharge chambers of monel.

Circulation rate was to be 11,000 gal./min. with a maximum requirement of 65 hp. The designed flow rate through the tubes was 4.5 ft./sec. Although this was a comparatively low velocity, it was necessary to keep the power required by the pump at a minimum.

It was also decided to use the old heater and the 20-in. pump on the second effect, so this old heater was lengthened to 22-ft., and 1-in. O.D. 90/10 cupro nickel tubes were installed in the old Monel tube sheets. The old 20-in. Morris axial flow pump was returned to the manufacturer for reconditioning. This pump had been in continuous service for almost nine years; the cost of reconditioning was only $1,800.

The new pans were shipped in six pieces, all sections matched-marked with assembly angles welded on. The pans were assembled horizontally on a roller cradle, which enabled the making of all welds in a down-hand position. After welding was completed, the pan was lifted by pivot pins, turned vertical, and dropped into position. The accessory equipment such as level control, salt drawoff legs, etc., was similar to that used on the old calandria pans.

The first of these units was put into service in January, 1953; the second in April, 1953; the old third and fourth effects were left in operation. The supplemental piping such as feed lines and wash lines were installed of Kroylastic plastic 3- and 4-in. size, with cemented joints and fabricated plastic fittings. The latter failed to stand up in service and these fittings were replaced with bronze-threaded fittings, and threaded plastic couplings. All necessary accessory fittings on these pans were of monel and were welded into the shell and circulating lines.

New evaporator pan being placed in position after its six sections had been welded together.

In general, steel pipe is used for brine lines, and in all instances where connections were made to the new pan lines, plastic sections were inserted.

After a short period of adjustment the operation of these two new pans was quite successful. Production capacity of the quadruple effect increased to 500 tons/day, and the lengths of the operating cycle were limited only by the two old pans. A continuous run of twenty-one days without any type of wash was made, but the salt scale on the walls of the old pans indicated that long runs were dangerous; the salt coaming was almost 2 ft. thick at the operating level of the old pan. This run enabled one to decide that the new pans could be run continuously for an indefinite period. Examination before washing after this run showed no salt coaming accumulations more than 1 in. in thickness, and this adhered mainly at the welds and was very spotty.

The salt-removal system had been adapted to handle lumps of small size, hence, only minor interruptions in the removal of salt were encountered. After several months the operators became more familiar with the new pans; operating controls were established and the salt scale trouble became a negligible factor as long as continuity of operation was maintained.

In August, 1954, the condensate from the first effect went salty. Examination of the heater showed a small hole through the wall of the tube just above the bottom tube sheet. In the following weeks similar tube failures occurred; after four tubes had failed the heads were removed and the tubes taken out for examination. All failures were similar.

A groove had been cut in the tube where it had been in contact with the monel tube sheet. In some cases this groove had started directly up the tube a short distance, turned at right angles, traveled circumferentially around the tube for an inch, then turned 90 degrees and continued up the tube. The groove ended just at the tube sheet where a small hole had corroded through the tube wall. All leaks were on the bottom tube sheet.

This type of corrosion was caused by insufficient rolling of the tubes. This end of the heater had been hand-rolled at the plant. The tubes were rerolled with the use of an electropneumatic tube roller; the tube failures then became infrequent. It has been twelve months since the last one, although there were four similar failures in the tubes of the second effect which had also been rolled by hand.

(*Continued on page 62*)

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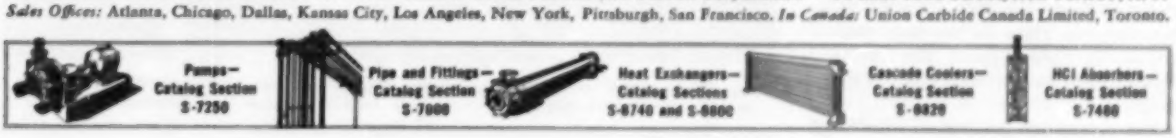


Tower of Learning at the University of Pittsburgh symbolizes the city's cultural growth.

PITTSBURGH: industry and the

M. M. Ramer | Blaw-Knox Co.

Twin towers of the University of Pittsburgh and the Alcoa Building symbolize the "new-look" of Pittsburgh, host city for A.I.Ch.E.'s National meeting September 9-12, which offers ideal facilities, recreation, plant trips and entertainment to visiting engineers.

Pittsburgh, perhaps the most dynamic city in America today, is an appropriate site for A.I.Ch.E.'s next national meeting, September 9-12. Long synonymous with smoke, soot, slag heaps, floods and apathy, and still just that to many who have not seen what *Life* magazine calls "Mellon's Miracle," Pittsburgh is now in the throes of one of the most dramatic physical and cultural renaissances in our history.

With the "Golden Triangle," the 36-acre New Point park where the Monongahela and Allegheny rivers merge to form the Ohio, the gleaming new modern buildings of Gateway Center, Pittsburgh is now a city of clean new buildings, large recreation centers, a symphony orchestra, great art collections, theaters and fine restaurants.

Chemicals Third

But industry is still the major concern of Pittsburgh, and plant trips are going to assume even more importance than usual at the Pittsburgh meeting.

While steel and iron are still king in Pittsburgh, chemicals, firmly based on the by-product coke oven, natural gas, petroleum, and other mineral resources of the area, rank third in the city's production. From Kopper's gigantic butadiene-styrene plant to the new nuclear reactor at Shippingport, the chemical engineer will have a "field day" in Pittsburgh.

The production position of Pittsburgh is well known, but its position as one of the world's great research centers is not as well known.

In the Oakland section stands the pivot of the city's research—Mellon Institute. Nearby is the most completely integrated petroleum research laboratory in the world, that of Gulf Research and Development at Harmarville where 1,270 scientists and engineers work in 40 buildings. In recent months alone, nearly $35 million worth of new research buildings have been added by Alcoa, Allegheny Ludlum, Gulf, Crucible Steel, Koppers, Pittsburgh Plate Glass, Robertshaw-Fulton, Westinghouse and many other firms in the area.

At the other corner of its research effort, Pittsburgh is the home of five colleges and universities, including two the engineers will have to visit: The Univ. of Pittsburgh and Carnegie Tech.

No story of Pittsburgh as an industrial center would be complete without mention of its position as the largest inland river port, handling more water tonnage than the Panama Canal. The Monongahela is probably outranked in river tonnage only by the Yangtze.

Fort Pitt to Golden Triangle

From the Fort Pitt blockhouse in New Point Park (built in 1760) to the $40 million Greater Pittsburgh Airport building, the world's largest, Pittsburgh

THE CHEMICAL INDUSTRY IN PITTSBURGH

CHEMICAL COMPANIES

American Cyanamid
Columbia-Southern Chemical Corp.
Hagan Corp.
Koppers Co.
Magnetics, Inc.
Neville Chemical Co.
Penna. Industrial Chemical Corp.
Pittsburgh Coke & Chemical Co.
Pittsburgh Plate Glass Co.
Rockwell Mfg. Co.
Stauffer Chemical Co.
Stoner-Mudge, Inc.
Watson-Standard Co.

PROCESS INDUSTRIES WITH CHEMICAL OPERATIONS

Allegheny Ludlum Steel Corp.
Aluminum Co. of America
Climax Molybdenum Co.
Copperweld Steel Co.
Crucible Steel Co.
Gulf Oil Corp.
Harbison-Walker Refractories Co.
H. J. Heinz Co.
Jones & Laughlin Steel Corp.
Mine Safety Appliances Co. (Callery Chemical Co.)
Pittsburgh Consolidation Coal Co.
Robert W. Hunt Co.
St. Joseph Lead Co.
U. S. Steel Corp.
Universal Cyclops Steel Corp.
Vanadium-Alloys Steel Co.
Vitro Corp. of America
Westinghouse Air Brake Co.
Westinghouse Electric

ENGINEERING RESEARCH AND CONSULTING ORGANIZATIONS

Bituminous Coal Research, Inc.
Blaw-Knox Co.
Mellon Institute
Nuclear Science & Engineering Corp.
Rust Engineering Co.
U. S. Bureau of Mines

Skyscraping Alcoa Building, with its bright aluminum sides, shows Pittsburgh's "new look."

golden triangle

SHIPPINGPORT NUCLEAR POWER PLANT TRIP

Special attraction for all chemical engineers is the major plant trip to Westinghouse and Duquesne Light Company's industrial power nuclear reactor at Shippingport. E. L. Ohsol, chairman of the Plant Trip Committee, has announced that arrangements are now completed for this trip of special interest to the chemical engineer.

offers sights, recreation, entertainment for every engineer.

There is the blue State Office Building, one of the first structures in the world to use siding of colored aluminum panels. Facing convention headquarters in the William Penn Hotel is Mellon Square—an acre of trees, shrubs, fountains and cascades, Venetian terrazzo and underground parking, all in the heart of the city and without peer in the nation.

Pittsburgh's cultural and recreation center is Oakland, only a few minutes ride from the William Penn. Here is the home of the great Pittsburgh Symphony, the Pittsburgh Playhouse, the Civic Light Opera and the Pittsburgh Opera. Here too is the 1 million volume Carnegie Library and Forbes Field where the Pittsburgh Pirates could be winning a long-awaited pennant at meeting time. Carnegie Art Institute is here, with canvases from the Middle Ages, the 18th Century, and the 20th Century. For the home gardener and the flower lover there is the magnificent Phipps Conservatory.

For the evenings and the inner man, Pittsburgh offers Broadway shows in the Nixon Theater, all the latest films in its downtown movie houses (including one of the few showings of Cinerama outside New York), and restaurants to suit every palate. In the city there is the Cameo, Chinatown Inn, Danny's, Frenchy's, Gateway Plaza, Klein's, Kramer's, Old Vienna, Park Schenley, Poli's, Royal York, Sorrento, Three Brothers, and many hotels. In the suburbs, if a drive in the country suits your fancy, there is Ben Gross, Bali Kea, Colonial Manor, Gammon's, Hi Ho, Lotus Garden, Mona Lisa, and many others. Want dancing and a floor show? Try the Ankara, Beverly Hills, Copa, Dore's, Ginny Lou, Holiday House, Horizon Room, Twin Coaches, White Elephant, and more.

A.I.Ch.E. secretary Van Antwerpen views packed schedule for September meeting with aid of (l. to r.) H. B. Coats, general chmn.; J. McAfee, vice-general chmn.; Mrs. H. B. Coats, co-chmn.—Ladies Program; and R. Rhodes, chmn. of Pittsburgh Section.

For The Ladies

Pittsburgh has more large department stores than any city between New York and San Francisco. The ladies can browse and buy to their heart's content.

Another favorite with the ladies is a tour of the H. J. Heinz Co. food plant, largest of its kind in the world.

This is just a small sample of some of the special attractions for the ladies in Pittsburgh, plus the program being arranged for them, of course.

The Big Picture

Finally, no engineer can afford to overlook a trip on the incline railway up to the top of Mt. Washington, where he will see the whole story of Pittsburgh—a panoramic view of the Golden Triangle, Gateway Center, Point Park, the rivers, and the endless towers and factories of Pittsburgh industry.

SALT EVAPORATOR

(*Continued from page 58*)

At the end of two years no other signs of corrosion had appeared. The performance of the heater and circulating pumps of the new pans remains excellent. The interior of the pans had taken on a glossy polished appearance.

Micrometer measurement of the four tubes removed showed no measurable loss in the wall thickness after nineteen months of operation. Analysis of the salt produced in these pans showed no increase in copper content compared with the salt produced in the cast iron calandria pans, and continued analysis of the copper content of the circulating brines indicated that this copper content was continually decreasing.

In June, 1955, two additional pans were erected and placed in operation. These pans were similar to the first two but were 15 ft. diam. with heaters containing 8,000 ft. heating surface with 26-ft. tubes. The same 24-in. pumps were installed operating at the same speed as the first-effect unit; while this results in a lower transfer coefficient, when the pumps are speeded up they will give additional production if needed.

In the operation of these new pans continuity of operation is important; a serious variation in the amount of steam fed causes the immediate loosening of the thin scale on the walls of the evaporators, some of which is carried into the circulating system, plugging some of the heater tubes, which results in decreased production. This is only temporarily serious, for the pans are installed with sufficient head above the heaters to prevent boiling in the plugged tubes. Hence, the tubes are readily cleaned during the washout.

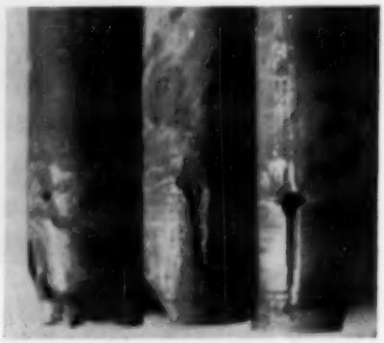
Evaporator History

The old pans were installed at the Watkins Glen Plant in 1907. They were of the short-tube vertical type, quadruple effect, with cast iron bodies, cast iron tube sheets, central downtake, and copper tubes of German design fabricated and installed by Bartlett Hayward. Each body was 22 ft. diam. and contained 1,220 3½-in. O.D. × 67-in. tubes, which gave a heating surface of about 6,000 sq. ft./effect. The downtake was 9 ft. diam. and contained a propeller.

The large diameter tubes and low liquor velocities resulted in $CaSO_4$ scale formation in the first-effect pan; this scale was removed monthly by mechanical means. A production of 20 hr. with 4 hr. taken for dumping brine, filling with water, washing, dumping, and again refilling (mostly with the same brine which had been dumped) was the daily procedure for the first thirty years.

The brine used at this plant is relatively high in the so-called bittern salts; it contains 6 to 8 gal./l. $CaCl_2$, 2.5 gal./l. $MgCl_2$, about 0.6 gal./l. KCl, 300 gal./l. NaCl, and is saturated with $CaSO_4$. Over the past twenty years the hydrogen sulfide content has increased to approximately 10 p.p.m. Corrosion of the cast iron of the pans was always a major problem because of the resulting small pieces showing up in the dried product. Aeration of the brine has been the practice for years, but the corrosion continued.

In 1936 a new operating procedure was developed, based upon operating the pans with a $CaCl_2$ content of 60-80 gal./l. The solubility of $CaSO_4$ in brine decreases quite markedly as the $CaCl_2$ content increases and, if this high $CaCl_2$ content is maintained, the $CaSO_4$ in the feed brine immediately precipitates upon entering the vacuum pan. This procedure eliminated the $CaSO_4$ scale on the tubes of the first and second effect, and the frequency of the wash was reduced to once every two days or even longer.



Above, grooving and perforation at lower tube sheet and below, cross section through tube at perforation: 1¼-in. O.D. × 0.065 in. wall cupronickel 10%-755 tubes from No. 1 heater, Glen Works, International Salt Co.

By 1942 the tube sheets of No. 1 pan had corroded so much that tubes could not be rolled in the sheets and major repairs became necessary. The replacement of the whole heating section of this pan would have been extremely costly since the original pattern had been destroyed. Hence, consideration was given to installing an external heating unit.

The operating technique had improved to the extent that tube scale was not a factor, but the power required for circulation of the brine was important.

In order to keep this as low as possible 1-in. O.D. tubes were selected for the heater. The heating element on this pan consisted of 1,220 1-in. O.D. copper tubes, 17-ft., 4-in. long installed in cast iron tube sheets; cast iron was selected for the brine circulating lines; and a Morris 20-in. axial flow pump of type 316 stainless steel was installed in the circulating line. The flow through the heater was estimated at 7,000 gal./min. and the heating surface 4,650 sq.ft. A coefficient of 500 B.t.u./sq.ft./F.°/hr. was used in designing this unit.

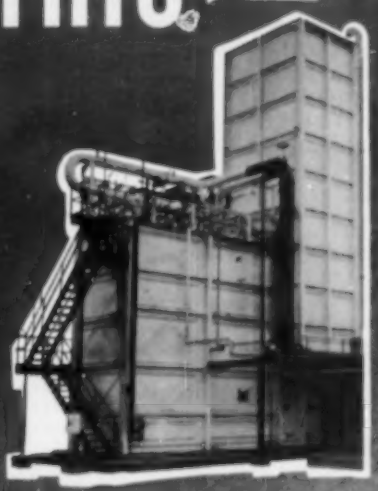
After several months this unit was working satisfactorily. The main difficulty encountered was the tendency of salt deposits to form at the tube inlets; this condition reduced the circulation. This unit more than replaced the 6,000 sq.ft. calandria heaters. The production of the quadruple effect was increased by 80 tons/day and the period between washes further increased to three or four days.

After operating for some time it was apparent that selection of the metals was not satisfactory. Pitting of the cast iron tube sheets adjacent to the copper tubes became serious. The copper tubes roughened with signs of copper plating on the old cast iron of the pans. At the end of three years it became necessary to install new tubes and tube sheets. This time Monel tube sheets with Admiralty tubes were installed. The use of Admiralty metal was not from choice; copper tubes were not available. This metal combination was fairly successful from the standpoint of corrosion. A considerable number of tubes were replaced because pieces of iron scale became wedged in the tubes, directing the brine against the wall of the tubes and eventually cutting a hole through the tube wall. These Admiralty tubes lasted the best part of four years when the heater was taken from service.

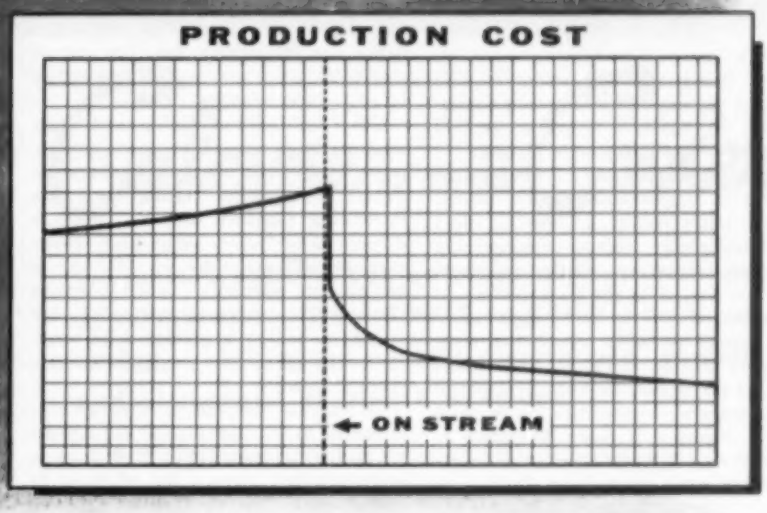
During the period of 1941 to 1949 the operating technique had been worked out to the point where week-long runs without washouts were commonplace. A second heater had been installed on the second-effect pan. The shutdowns were made usually because of needed repairs to the accessory equipment. These interruptions necessitated changing pumps, valves, etc., from cast iron and Ni-Resist to a 25-20 stainless alloy, the salt slurry was handled in nonferrous pipe, and in some instances rubber hose was used for feed lines. Automatic level controls and a steam-pressure controller were added to maintain constant pressure on the first effect. Flowraters were installed on the feed and washing leg brine supply lines. These additions and changes resulted in improved continuity of operation. However, during this period one real concern was the presence of iron oxide specks in the salt. Magnets had been in use for years, hence complaints were not common, but it appeared that cast iron was not a suitable metal for a salt evaporator when operated on the brines this plant was using.

Presented at A.I.Ch.E. Forty-eighth annual meeting, Detroit, Michigan.

When THIS goes on stream



THIS goes down



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CONTROL OF RESEARCH COSTS

While most executives will agree that no company can prosper long without research, it is difficult to prove that this is so, or to answer such questions as how much to spend on research, how to judge whether research money is being spent wisely, or how to discover if, and at what rate, research has really earned money for a company. There are no easy formulas to supply answers to these questions, but there are certain things which will help in the formulation of judgments apart from the crystal ball.

M. T. Carpenter | Standard Oil Company of Indiana

In a consideration of research costs, probably the first thing to decide is the amount of money the company plans to spend on research at present and the size of the program in the foreseeable future. This will set an upper limit on the research budget. It may be decided that a smaller budget would be better for any given period, since it is sometimes necessary to think of such things as inability to recruit qualified personnel, lack of space, or lack of capital to put successful research results to work.

Any decision should recognize that research is primarily a long-range proposition. It cannot be turned on and off without doing irreparable damage to the company's program. Expansion of a research organization can be accomplished fairly readily, at least in times when technically trained personnel are available. However, if the expansion goes too far, it might be necessary at some future date to curtail operations. This would probably mean that some members of the technical staff would have to go. Research and development in a modern organization is a team effort. Nothing is more disruptive to team morale than the enforced withdrawal of some members to other work.

How Much to Spend?

A number of indices have been suggested for determining how much research should be done. None of these is satisfactory. At best they can be used only as rough guides, since actual practice in different industries varies widely. Even within a given industry there will be wide differences between various companies. For example, in 1951 the aircraft industry spent about 12.7% of sales on research, while the food and kindred products industry spent only 0.3% of sales. The petroleum industry, which is usually considered a leader in research and development, spent 0.6% of sales for these activities in 1951. Differences between companies within the aircraft industry vary from less than 2% to more than 25% (*1*).

With variations such as these it is quite apparent that a single company can get little help from such statistics in determining its own research policies. Nevertheless, it does appear that each industry establishes a pattern of its own. For example, many chemical companies spend about 3% of sales for research. The more progressive of the petroleum companies usually spend a little less than 1% of sales. But while these statistics are interesting, they are not of real value when a decision is necessary in any given situation.

Other indices, such as research costs as percentage of net or gross profits, percentage of net worth, and others are of no more value. Again, these are interesting statistics and the research director should know about them. However, he will find them of little use in solving his particular problem unless perchance he might be tempted to use one as a selling argument with management to support a request for more research money.

Ordinarily, the research director recommends to his management the amount of money necessary for the projects underway and gives a list of those he cannot carry out because of lack of funds in the current budget. He should first decide which items are an absolute "must." These will include projects which will protect the business of the company. Probably there are a few more that look so promising that it would be stupid to stop them. The cost of carrying out projects in both these fields should be considered the *minimum* research budget.

A good research director will always have more ideas on the docket than his staff could possibly work on. These ideas will be in various stages of development, so far as being projects is concerned. Some will be in the "gleam in the eye" stage; others will have had some exploratory work done on them. The research director has to decide how many of these ideas are good. The decision on any given project should recognize the possible profits, if successful. The state of the company's finances has to be considered—there is no use in doing a lot of research work unless the company has enough capital to put the idea to work. Also, the question of whether the idea represents a logical extension of the present line of the company's business, or a diversification into a new field must be studied. If the latter, the question of the company's readiness to diversify arises.

Generally speaking, the research director's preliminary budget will be substantially larger than any previous budget he ever has had approved. He must, then, pare down this preliminary estimate, dropping some projects, spending less money on others. These decisions are strictly a matter for the research director to fight out with his own conscience. Then he has to convince the management of his company. There are no rules covering how this should be done, for these are strictly matters of judgment—the technical judgment of the research director, the business judgment of management. In the long run the success of the business will depend upon the soundness of these judgments.

Wise Spending

Finally a research budget will be approved. What kind of controls are needed to administer these funds?

Once a research budget has been approved it should be thoroughly understood by all concerned that the approval gives authority to the research director to spend the amount of money approved. It should not be considered a promise by the research director that the budgeted amount of money will be spent on each project. As the work progresses the research director should have freedom to shift emphasis from one project to another, to drop some projects and to start up others just as long as he stays within the amount of money approved—or, as will be discussed later, the number of people approved (*2*).

After the amount of money to be spent on research in any given year is determined, it is important to establish controls to insure that the budget will not be exceeded. Establishment of these controls can also provide a mechanism for keeping track of how much money is spent on each project.

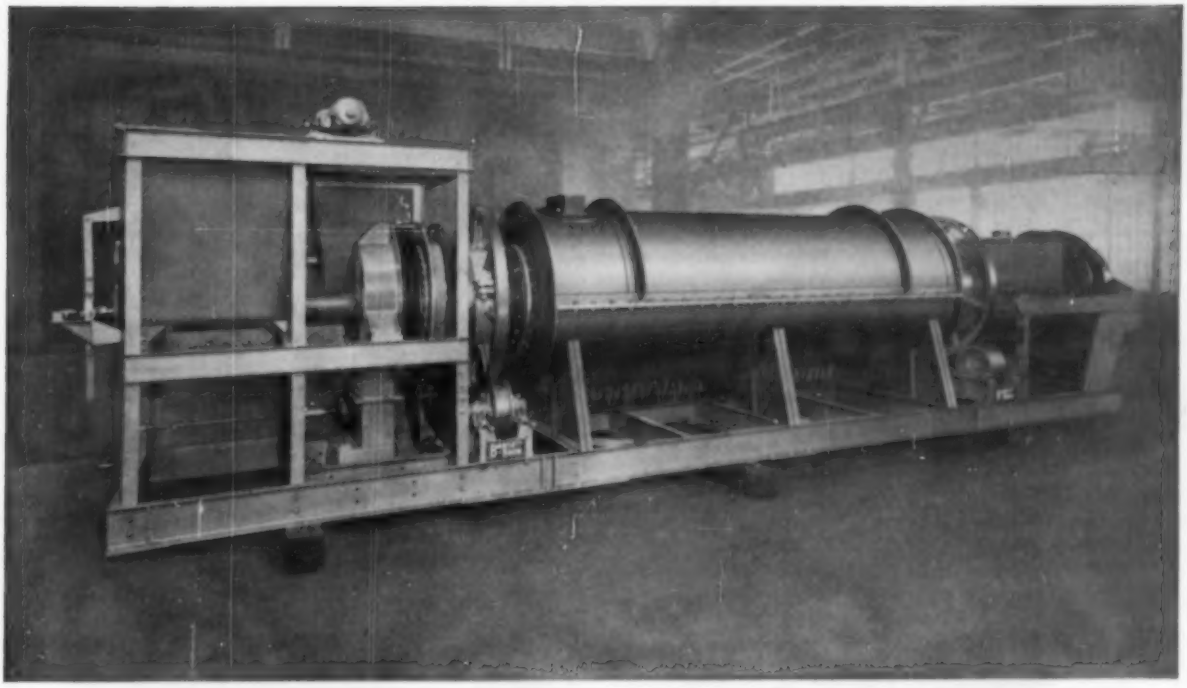
Analysis of the costs of many research organizations in different industries reveals that these costs can be classified into three groups:

a. people
b. supplies, materials, and equipment
c. overhead

It will be shown that all the costs of operating a research organization can be related to people. If this is done,

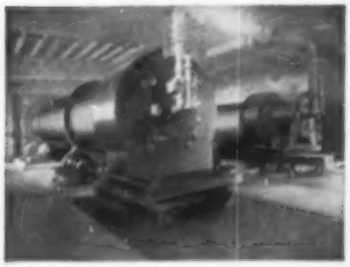
(*Continued on page 82*)

[*] Mr. Carpenter is administrative director of the research department at Standard of Indiana and is also president of the Scientific Manpower Commission.



continuous Calciner and Cooler

Two Bartlett-Snow Rotary Oil-Fired Batch Kilns Pre-heating Charges for Electric Furnaces.



Two Oil-Fired Continuous Kilns Working Temperature 2300° F.

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A typical Struthers Wells CIRCULATING HEATING SYSTEM serving a major Canadian oil refinery

The Dowtherm heaters shown above are installed in the plant of a major Canadian oil refiner. The heaters are part of Struthers Wells circulating heating systems, utilizing liquid Dowtherm as the heating medium, at temperatures of approximately 700°F.

This equipment is used to supply process heat for reboilers and other heat transfer equipment, as installed in a modern lubricating oil refining operation. This type of equipment insures close temperature control and high heat transfer rates in the users. The capacity of these systems is 60,000,000 BTU per hour, making it one of the largest installations of this type.

Struthers Wells is a major supplier of circulating heating systems for both liquid and vapor service, and utilizing commercial heat transfer fluids in a wide temperature range. Hundreds of successful installations, many of them repeat orders, provide a wide background on which to base recommendations for any type of service.

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STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

MACHINERY DIVISION

MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

STRUTHERS WELLS *Corporation*

WARREN, PA.

Struthers Wells

Plants at Warren, Pa. and Titusville, Pa.

Offices in Principal Cities

Please do not use this card after September, 1956

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Advertisers' Products

IFC	3R	4A	6L	7A	8A	9A	10A	11A	12L	13A	
14A	15A	16A	17A	18L	19A	25A	26A	27A	28A	29A	
30L	31A	32A	33A	34A	36L	37A	38A	39A	40L	41A	
42A	43A	44A	45A	46L	47A	48L	49R	50A	51-52A	54A	
220A	55A	57A	59A	63A	65A	66A	71A	73A	75A	77A	
79A	81A	82L	83A	84L	85A	87A	88T	88B	89R	90L	
91R	92L	93R	95R	96L	97R	98L	98R	99R	103R	104TL	
104BL	104BR	105R	107TL	107BL	107BR	107TR	109L	109R	110L		
111TR	111BR	112TL	112BL	113R	114BL	115R	122L	124L	124BR		
125R	IBC	OBC									

Chemical Engineering Progress Data Service

Name .....

Position .....

Company .....

Address .....

City .....Zone.....State.....

☐ I want a subscription to C.E.P. Bill me $6.00 for a year.

June, 1956

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129	130	131	132	133	134	135	136	137	138	139	140	141	142

Advertisers' Products

IFC	3R	4A	6L	7A	8A	9A	10A	11A	12L	13A	
14A	15A	16A	17A	18L	19A	25A	26A	27A	28A	29A	
30L	31A	32A	33A	34A	36L	37A	38A	39A	40L	41A	
42A	43A	44A	45A	46L	47A	48L	49R	50A	51-52A	54A	
220A	55A	57A	59A	63A	65A	66A	71A	73A	75A	77A	
79A	81A	82L	83A	84L	85A	87A	88T	88B	89R	90L	
91R	92L	93R	95R	96L	97R	98L	98R	99R	103R	104TL	
104BL	104BR	105R	107TL	107BL	107BR	107TR	109L	109R	110L		
111TR	111BR	112TL	112BL	113R	114BL	115R	122L	124L	124BR		
125R	IBC	OBC									

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the chemical engineers'

DATA SERVICE

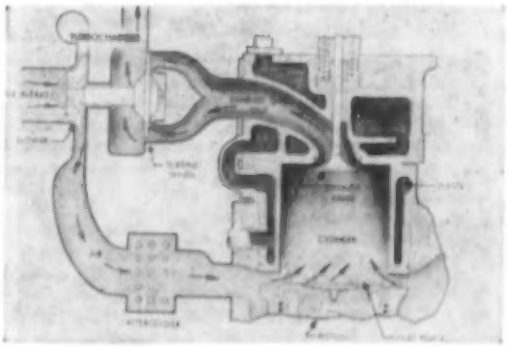
and

GUIDE

to significant developments in

- **EQUIPMENT**
- **MATERIALS**
- **SERVICES**

developments of the month—



Schematic diagram of Worthington's Turbo-Uniflo system.

86 NEW GAS ENGINE COMPRESSOR known as the SUTC Turbo-Uniflo is announced by Worthington Corporation. Available in 750-2,500 hp range, the newly designed engine-compressor is the only two-cycle spark-ignition gas-engine compressor operating with a completely independent exhaust gas-driven turbocharger.

Operating at relatively high compression ratio, the Turbo-Uniflo has smooth combustion characteristics due to the basic timing arrangement, engine configuration, and design of the exhaust manifolding. Results in quieter operation, low fuel and lube oil consumption, and low bmep—96.1 lbs./sq.in. at rated speed and load. Complete absence of residual gases in the combustion chamber results in high turbocharging-scavenge ratio.

Design permits engine's exhaust to be applied to the turbocharger which starts and runs with no other external mechanical drive. More power, greater efficiency and reduced maintenance costs are benefits of the new design.

(Continued on page 68)

TURN THIS PAGE TO RIGHT FOR MORE . . .

HOW TO USE THIS POST CARD FOLDER

Merely encircle numbers on cards to get literature desired. On advertised products in front of magazine, fold this page out to right. For those in back, fold card strip again to right, where card strip is scored for detaching.

products-

advertised in this issue

IFC Chemical Plant Construction. Vulcan Construction Div., Vulcan Copper & Supply Co. is ready to take over the building of your new chemical plant from preparation of the site to final operation. Also renovates existing plants of any size.

3R Feeders. Maximum efficiency without danger of overloading results with use of Draver feeders. Eliminates wasteful reprocessing. B. F. Gump Co.

4A Demisters. Process vessel performance improves with clean separation of liquid from vapor. Bulletin 17 from Otto H. York Co., Inc. lists case histories using Yorkmesh units.

6L Oxygen Analyzers. Control of oxygen in chemical processes whether to minimize or insure proper oxidation is a major consideration. Arnold O. Beckman Inc. units detailed in Data File 20A-66.

7A Mechanical Seal. Fabricated from Teflon design of this seal is simplified. Gives economical service on pumps handling corrosives. Application data available on Teflon & Zytel. E. I. du Pont de Nemours & Co., Inc.

8A Sulphur Burner. A new unit from Chemipulp Process Inc. permits molten sulphur to be sprayed into burner as fine mist. Capacities 1 to 25 ton/day of rated capacity.

9A Molecular Sieves. Air, hydrogen, or chemical streams said to be dried more thoroughly using Linde Air Products Co. molecular sieves. Data sheets available from fabricator.

10A Pumps. Both standard motor-driven & exclusive step-valve liquid end types are the products of Milton Roy Co. See list of available bulletins.

11A Carbon & Graphite Products. Engineering service of Great Lakes Carbon Corp. available for technical advice to electrode, anode, carbon brick & mold stock clients. Customer needs & wishes anticipated.

12L Plastic Pipe. Called Rivicior this new rigid plastic pipe gives superior resistance to chemicals & has good aging characteristics, high strength, easy workability. Technical bulletin CE-56. American Hard Rubber Co.

13A Catalysts. The plus values of Girdler Co. catalysts lie in their application, development, analytical & market services plus advanced production.

14A Process Equipment. Conkey crystallizers, evaporators, & filters will remedy your problems in those areas. Conkey engineers in your vicinity available for advice. Chicago Bridge & Iron Co.

15A Centrifugals. You too can use a time-saving, profit-making method by employing De Laval Separator Co. units. Make separation continuous, eliminate production bottlenecks.

16A Insulation. Five reasons why Asbestocite asbestos-cement sheets will give your equipment better protection are listed. Free brochures available from Johns-Manville.

17A Pumps. Illustrated is a pump used in vinegar service since 1928 & exposed to fire. Still operating without repacking in past five years. Duriron Co., Inc. pumps designed for long life & trouble-free service.

18L Piping. Packless Metal Hose, Inc. offers seamless flexible metal hose designed, engineered & fabricated to absorb shock resulting from sudden changes in temperature & pressure. Available from stock in variety of materials.

19A Process Equipment. A complete & diversified line of process equipment is available from Allis-Chalmers. Bulletin (25C6177) covers the line.

25A Dowtherm. Eliminate off colors & spoiled batches. Increase resin & drying-oil quality by using precise uniform process heating with Dowtherm. Bulletin DO825B filled with facts. Dow Chemical Co.

26A Process Systems. Stephens-Adamson Mfg. Co. engineers systems for conveying materials at low per ton cost. Contact the sales engineer in your area.

27A Controller. You can eliminate costly, dangerous "overshoot" problem using a Foxboro Co. batch controller. Information available.

28A Filters. Units for vacuum & pressure operation are in use in a long list of industries. Filters for slop oil save money. Eimco Corp.

29A Centrifugal Compressors. Illustrated are three basic types of Ingersoll-Rand Co. units. Complete range of sizes in each type. Engines, drills, pumps, other equipment available.

30L Teflon Shaft Seals. Chemiseals from U. S. Gasket—Belmont Packing fabricated from Teflon rotate with shaft & avoid scoring. Sizes ⅞ to 2⅛ in. Maximum length is 5/16 in. Bulletin MS-1155.

31A Molybdenum Catalysts. These materials resist poisoning when sulfur is removed from petroleum stocks. For technical data ask for "Molybdenum Catalysts for Industrial Processes," from Climax Molybdenum Co.

32A Valves. Available in 18-8 SMo & Craneloy 20 in gate, globe, angle & check patterns, sizes ½ to 6 in. Circular AD-2080 available from Crane Co.

33A Heating, Mixing, Cooling. These operations shown in flow diagram provide better grease at lower cost using units from Votator Div., Girdler Co.

34A Mineral Filler. Called Celite, material said to give ten times greater bulking-action than other like materials, Johns-Manville.

36A Heat Exchangers. For oil & water coolers Paracoil type P exchangers. Built with standard components units said to minimize thermal change stresses. Davis Engineering Corp.

37A Flowmeter. Easily installed in any type piping to operate at any angle an electronic unit. For pressures & temperatures —450 to +1200° F. Potter Aeronautical Co. Bulletin PS-1.

38A Filter Media. Diatomaceous filter material called Dicalite. Great Lakes Corp. make advisory & test services available for in plant or their laboratory to solve your problem. Dicalite Div., Great Lakes Carbon Corp.

39A Stainless Steel Tubing. Mr. Tubes of Babcock & Wilcox Co. will aid you in choosing correct grade for your need. Bulletin TDC-160 CEP available.

40L Swivel Joints. Emsco ball-bearing swivel joints found on many vital installations. Ball race design plus other features result in profit to you. Emsco Mfg. Co. Catalog available.

DEVELOPMENTS OF THE MONTH *(Cont.)*

87 MECHANICAL LIQUID METAL PUMP by Westinghouse Atomic Equipment Department will operate at temperatures up to 1,600° F. for use in nuclear power plants, chemical process lines, and other applications requiring high-temperature heat-transfer mediums. Rated 150 gpm at a 285-foot head, the new centrifugal pump has a hermetically-sealed "canned rotor" which contains pump and motor rotor in one integral unit. This isolates the pumped fluid and all rotating parts from the field windings and outer atmosphere. Production models will operate at temperatures up to 1,600° F., will be applied to nuclear power plants, chemical process lines, & other applications requiring high-temperature heat-transfer mediums.

(Continued on page 69)

41A Fertilizer. A complex fertilizer results in balanced plant food. Chemical & Industrial Corp. design & build plants for ammonia processing anywhere in the world.

42A Process Equipment. Fabricated from glassed steel units provide high corrosion resistance in addition to other benefits. Capacities to 2100 gal./8 hr. day. Pfaudler Co.

43A Ammonia Plants. A new trend in ammonia plants introduced by Lummus Co. design engineers & constructors for petroleum & chemical industries.

44A Process Filters. Various types of filters available from Process Filters, Inc. are illustrated. Information available on special financing.

45A Plastic Rotary Pump. Design of the Vanton Pump & Equipment Corp. Flex-I-liner pump eliminates stuffing boxes, shaft seals, gaskets & check valves. Materials of fabrication listed.

46L Heat Exchangers. Extended-surface units for heating, cooling, processing or air conditioning. Ask for Aerofin man nearest you. Aerofin Corp.

47A Plant Design & Construction. Pioneering achievements in a long list of fields attest to ability of Catalytic Construction Co.

48L Pollution Problems. Called Aerovane a system for offsetting air pollution problems. Units may be purchased separately for use with transmitter. Complete information available. Bendix-Friez Instrument Div., Bendix Aviation Corp.

49R Industrial Demineralizer. Design & construction of complete water treating plants & waste treatment systems is the specialty of Industrial Filter & Pump Mfg. Co. Write for Bulletin 200.

50A Plant Construction. Whether your problem is procurement or construction, setting machinery or plant maintenance Graver Construction Co., Inc. is prepared to do your job.

51A Lubricated Plug Valves. Rockwell-Nordstrom valves are available in complete range of sizes & pressure ratings. Operate instantly; shut off positively. Rockwell Mfg. Co.

54A Spray Dryer. See the list of cost-cutting features of the Buflovak spray dryer. Unit gives various materials new characteristics & markets. Blaw-Knox Co. Ask for bulletin No. 373.

55A Mixers. Called Turbo-Mixer unit is designed to meet rugged service requirements. Each type has correct impeller for optimum mixer efficiency. Turbo-Mixer Div., General American Transportation Corp.

DEVELOPMENTS OF THE MONTH *(Continued)*

Sturtevant production model Micronizer.

88 FLUID JET GRINDING MACHINES in a new series of seven sizes (½ lb./hr. to 3,000 lb./hr.) by Sturtevant Mill Co. are designed to reduce solids to particles in the micron range at a solid feed rate of up to 1½ tons/hr. The Micronizer has no moving parts, operates on the principle of high speed rotation of particles caused by jets of compressed air or steam at angles to the periphery of the shallow grinding chamber.

Sturtevant laboratory model Micronizer.

(Cont. on page 70)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

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BUSINESS REPLY CARD

First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

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First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

products-(Cont.)

advertised in this issue

220A Hot Spray Paint. Called Tygon "ATD" hot spray material gives paint film 5 mils thick in 2 passes of the gun. Stops corrosion. Protective Coatings Manual available. U. S. Stoneware Co.

57A Job Opportunities. If you are interested & qualify in any of the areas listed write the Caltech Jet Propulsion Laboratory.

59A Graphite Equipment. Because it costs less & lasts longer Karbate impervious graphite is used in constructing equipment from National Carbon Co. Literature available.

63A Oxygen & Nitrogen Stations. Air Products Inc. design & manufacture large tonnage capacity generators for unlimited quantities of oxygen & nitrogen regardless of size, purity, or cycle.

65A Calciner & Cooler. Unit permits materials to be processed continuously at temperatures from 900 to 1,200°F, in a reducing or other atmosphere cooled & discharged at 200°F or lower. Bartlett-Snow Co.

66A Circulating Heating Systems. Struthers Wells Corp. is a major supplier of such systems for both liquid & vapor service. Also build fired heaters for direct heating of process fluids.

71A Blender. A new liquid-feed twin shell blender from Patterson-Kelley Co., Inc. enables achievement of complete dispersion of liquids in minutes. Sizes 3 to 50 cu. ft.

73A Valves. Leslie Co. shutoff valves equipped with electric solenoid valves may be operated remotely with air or hydraulic relay valves. Bulletin 5309 describes operating valves.

75A Stainless Steel Valves. In order to make the Cooper Alloy Corp. stainless steel valve even better it is under continuous study. A plant clinic can be arranged for you. Ask for booklet "75 Questions."

77A Horizontal Dryers. See the list of solutions to process problems using horizontal dryers. For use in difficult operations listed. Advisory service available. Bethlehem Foundry & Machine Co.

79A Filters. Called Steynew, liquid filters for oils, water, chemicals, coolants. Constructed according to API-ASME codes, in variety of materials. Send for bulletin D-IL. Dollinger Corp.

81A Blenders. Sturtevant Mill Co. dry-batch blenders produce batches of 500 to 40,000 lb. exactly as you want them. Give four different vertical & lateral mixing actions. See list of bulletins.

82L Dryers. Built with any number of desired trays in various arrangements as desired, units remove 100 lb. of water from a 200 lb. charge in 8 hrs. at 60°C. Details available. C. G. Sargent's Sons Corp.

83A Pumps. To acquaint yourself with benefits from pump standardization & the right pump for a specific condition ask for Worthington Corp. bulletins.

84L Alloy Fabrication. Misco Fabricators, Inc. design, build & fabricate process equipment from corrosion resistant nickel-bearing alloys.

85A Plant Site. If you need coal & limestone Norfolk and Western Railway has such a site available to you.

87A Drying Equipment. Higher drying speeds result in increased profits. Wet-solid materials may now be handled efficiently by Proctor & Schwartz, Inc. units by pre-forming techniques.

88TL Walkways & Handrailing. High strength, non-corrosive aluminum units provide non-skid, non-sparking safety. Washington Aluminum Co., Inc. also builds process equipment.

88SL Filter Presses. The wide range of types & capacities of T. Shriver & Co., Inc. filter presses assure an economical unit for every filter need. Ask for catalog No. 55.

89R Plastic Pipe, Fittings, Valves. A choice of three types of plastics is available in the Vanton Pump & Equipment Corp. line. Described in catalog PL 101.

90TL Chlorination. Wallace & Tiernan, Inc. offer a chlorination system capable of correcting algae growths in your process. Write for Bulletin 2136-C.

90SL Feeders & Meters. Merchen units control feeding of ingredients by weight to accuracy of 1%. Capacities from 3 to 3,000 lb./min. Bulletin. Wallace & Tiernan, Inc.

91R Tantalum. Judged on an overall final operating cost basis tantalum often proves to be "cheapest." Fansteel Metallurgical Co. will be glad to tell you definitely whether it is cheapest for you.

92L Packing. Shallow stuffing boxes need the kind of grip that Garlock Packing Co. 431 Chevron packing gives. Two thousand styles of packing, gaskets & seals in line. Folder AD-115.

93R Heat Exchanger. The Niagara Blower Co. aero heat exchanger illustrated cools liquid for a large hydraulic press. Removes heat at rate of input without consuming cooling water except amount evaporated.

95R Steel & Alloy Plate Fabrication. Constructors of process equipment & fabricators of steel & alloy plate. Tower illustrated has 80 trays. Downingtown Iron Works.

96L Adsorption Material. Called Florex material comes in standard meshes from 2/4 to 200 & up. Advisory service of experienced adsorption specialists available. Floridin Co.

97R Filter Presses. With 60 years filtration experience D. R. Sperry & Co. are qualified to evaluate your specific filtration requirements. Complete information in catalog 7E.

98L Chemical Engineering Catalog. No matter what your need whether it be process equipment, materials of construction, or engineering services turn to this reference. Reinhold Publishing Corp.

98R Comparators. W. A. Taylor & Co. instruments help you control various process steps with fast, easy pH & chlorine analyses. Free Handbook available.

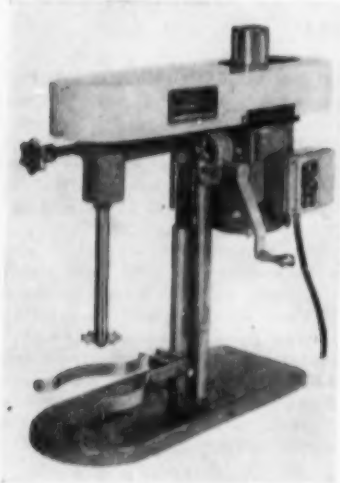
99R Control Valve. From Foster Engineering Co. a new control valve with Isoforce actuator. Gives more power when needed. Sizes start at ½ in. with materials & end connections to suit operating conditions.

103R High Alloy Pipe. Called Duraspun this centrifugally cast high alloy pipe is produced in O.D. ranging from 2½ to 24 in., lengths to 15 ft. according to diameter. Duraloy Co.

104TL Valves. Triple-action quick closing valves on all lines & tanks handling volatile or combustible produce close instantly in case of fire. Ask for bulletin GV-11. Vernon Tool Co., Ltd.

(Continued on page 72)

DEVELOPMENTS OF THE MONTH (Cont.)



89 LABORATORY MODEL DISSOLVER by Morehouse-Cowles features a continuously variable range of speeds from 1,900 to 5,900 rpm, with impeller speeds of 1,600 to 6,150 fpm depending upon impeller size. Greater handling speed and convenience in this Model 1-VG are made possible by a simple speed adjustment knob which eliminates cover removal, belt changes, and sheave change. Speed indicator plate provides for approximate rpm settings. Heavy duty drive and belt can pull full load capacity of the motor without slippage or power loss. Model 1-VG has minimum height of 21-5/16", with 10" width & 28⅞" length. Units designed for use with 2-gallon container. Net weight is 122 lbs. with standard 1 hp open type motor 178 lbs. with 1 hp explosion proof motor. Arrangements made for plant tests without obligation.

(Continued on page 72)

Actual laboratory pre-tests prove you can...

Blend liquids into dry materials fast, in one operation... without lumps

Getting perfect dispersions of liquids into dry materials without lumping has almost always entailed extra steps for pulverizing, mulling or screening, etc.

But P-K's new *Liquid-Feed** Twin Shell Blender eliminates those extra, costly operations. Now, in a one batch operation, you can achieve complete dispersion of liquids in a matter of minutes. Blender is charged through large dust-tight openings that allow easy access to shell interior for cleaning. Complete Liquid-Feed assembly is quickly removed by means of a spring loaded mechanism.

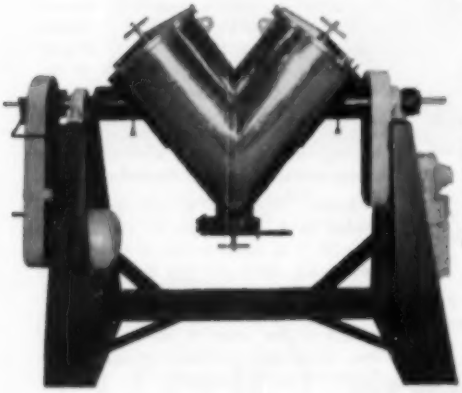
The Liquid-Feed blender is simple in concept. Liquid flows from a feeder tube within the bar onto a revolving distributing disc. Centrifugal force flings a fine spray outward. Dry materials tumbling in the Twin Shell receive liquid in controlled amounts at all times. The wire cage, spinning at high speed, prevents the formation of lumps before or after liquid is introduced.

Results? More perfect blends, in a fraction of time previously required. Want proof? P-K's Process Division maintains a complete lab to assure accurate, predetermined performance to meet your liquid-feed blending requirements. P-K will conduct, without obligation, laboratory test-blends with your materials.

Experimental testing will provide operational procedure and scale-up data. All test reports are held in strict confidence when desired, and, whenever convenient, testing may be supervised or witnessed by your personnel. P-K will submit complete factual test results, including samples of test-blends. Write direct to our Research Department.

The Patterson-Kelley Co., Inc.,
1760 Hanson Street, East Stroudsburg, Penna.

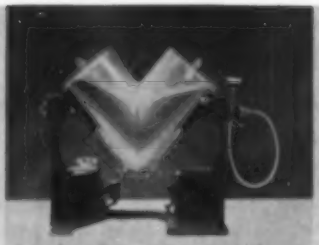
*patented and patents pending



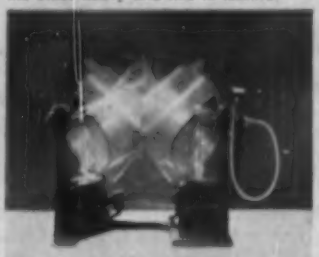
This production model is in stainless steel. Standard liquid-feed twin shell blenders are available in most commercial metals. Sizes range from 3 to 50 cu. ft. working capacity.

Patterson Kelley
Chemical and Process Division

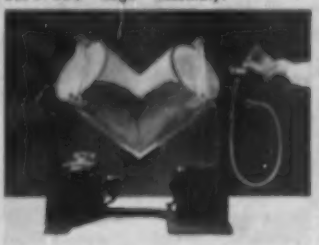
Twin Shell Blenders • Autoclaves • Pilot Plants • Heat Exchangers
Ribbon and Double Cone Blenders • Lever Lock Doors



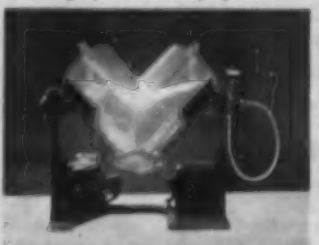
8 qt. blender is loaded for test with dissimilar materials, one lumpy and light, the other heavy and fine in texture.



Complete uniformity is obtained in a few minutes by dry blending. Lumps are broken up by fast-spinning intensifier bar's wire "cage" assembly.



Liquids are then introduced into the dry blend during rotation by gravity-feed. Distributing disc disperses liquid evenly. Wire cage prevents clumping.



Average blending time is approximately 15 minutes to obtain perfect liquid-feed mix. One step operation eliminates pulverizing, mulling and screening.

Discharging is easy. Stainless steel liquid-feed assembly ejects instantly, rinses in seconds. Seconds more to wipe clean the smooth, easy-to-get-at interior.

products-

advertised in this issue *(Cont.)*

104BL Rotary Pumps. Available from stock a low-cost, low-volume pump for corrosive liquids. Capacities 1 to 10 gal./min., pressures to 150 lb./sq. in. Request bulletin AC65. Eco Engineering Co.

104BR Spray Nozzles. A copy of Spraying Systems Co. reference manual will aid in improving your spray operation & lowering costs. Reference data on thousands of items.

105R Belt Conveyors. Design meets needs for solution to bulk conveying equipment. Includes all necessary parts for quick, easy assembly in your plant. Bulletin 1454 gives details. Stephens-Adamson Mfg. Co.

107TR Mixers. If you are in the market for versatile tilting batch mixers ask for Gruendler Crusher & Pulverizer Co. bulletin B-12.

107TL Gear Pumps. Schutte and Koerting Co. steam jacketed gear pumps for use in varied industries. Handle viscous materials of many types. Bulletin 17-A describes line.

107BL Pumping, Heating, Straining Units. Read what satisfied customers say about these units as indicated in the ad of Schutte and Koerting Co. Ask for bulletin 16H.

107BR Ejectors. Are you looking for low-cost vacuum? Ingersoll-Rand steamjet ejectors do the job. Sizes from 1 to 66 in. suction. See bulletin 9013-A.

109L Pumping Progress Report. Chemical engineers will be interested in this detailed report. Other information from the company. Aldrich Pump Co.

109R Syncrogear Motor. Both gearing & motor are custom built by U. S. Electrical Motors. Proven record of dependable service & long life under rugged conditions.

110L Multi-Wash Collectors. Dust, fumes, soluble or acid gases & odors all have yielded to the Multi-Wash action developed by Claude B. Schneible Co. engineers. Information available.

111TR Nozzles. Said to be most complete line of nozzles available. Capacities 1/8 pt./min. to 4,000 gal./min. Ask for catalog. Spray Engineering Co.

111BR Skin Protection. Kerodex is elastic as skin itself. Spreads as a cream but acts like a glove. Does not affect materials handled. Ayerst Laboratories.

112TL Filter Paper. Brochure offered by Eaton-Dikeman Co. enumerates dozens of products & tells specific grade paper to use. Ask for a copy.

112BL Process Equipment. Bowser, Inc. systems speed liquids from receipt to delivery. Include meters & fillers, proportioners & blenders, fillers & packagers. Available on lease or purchase.

113R Process Equipment. Investigate the list of units which Condenser Service & Engineering Co., Inc. designs & builds. Descriptive bulletins for the asking.

114L Air Stirrers. Ace Glass Inc. laboratory air stirrers are explosion proof. Powered by air units are completely safe, efficient, & economical to operate. See Supplement No. 1.

115R Silicone Defoamers. Said to be most economical & versatile foam killers ever developed. Boost productive capacity & cut process time. Dow Corning Corp.

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122L Fire Protection. Called Protectoseal these flame arresters at open vents protect high flash point solvents. Booklet on "Venting Fundamentals." Protectoseal Co.

124L Wood Process & Storage Equipment. Wendnagel & Co., Inc. design & build such corrosion resistant units. Ask for Chemical Equipment Bulletin.

124BR Visual Production Control. Called Boardmaster unit makes control operations simple. Over 60,000 in use. Ask for booklet X-10. Graphic Systems.

125R Chill-Vactor Units. Economical the year 'round these steam-jet units from Croll-Reynolds Co., Inc. have no moving parts, require no lubrication & cost little to maintain.

IBC Heat Exchangers. Brown Fintube Co. are fabricators of high pressure heat exchanger sections. Available for pressures to 22,000 lb./sq. in.

OBC Mixers. If you need help on a mixing problem contact a man from Mixing Equipment Co., Inc. A type of Lightnin mixer for every use. Ask for literature listed.

Technical Literature • Technical Literature • Technical Literature • Technical Literature

equipment-

1 Centrifugal Pumps. An all bronze, centrifugal condensate return pump that does not require a pit even though return pipes are more than a foot above the floor now available from Walter H. Eagan Co., Inc. Fitted with non-clogging open impeller, stainless steel shaft, life-sealed ball bearing, flexible coupling pipe connections.

2 Regulating Valves. Bulletin from Copes-Vulcan Div., Blaw-Knox Co. describes two new basic control regulating valves with greater versatility & wider application. Illustrated bulletin states these diaphragm & piston type valves handle water, steam, air, gas, oil, other similar fluids at unlimited pressures.

3 Radioisotopes. A revised catalog from Oak Ridge National Laboratory on Radioisotopes now available to scientific institutions, medical centers, industrial laboratories & others. Nearly 100 different radioactive preparations made & distributed by the Laboratory are listed with specifications & price.

Developments of the Month *(Continued)*

90 GLASSED STEEL RESISTIVITY to acid solutions is covered in a 12-page bulletin (No. 928) available from Pfaudler Co. Booklet includes information on temperature, concentration, and other factors affecting corrosion, resistance charts showing resistivity of Pfaudler glass to nitric, acetic, sulfuric, hydrochloric, and phosphoric acid solutions.

(Continued on page 74)

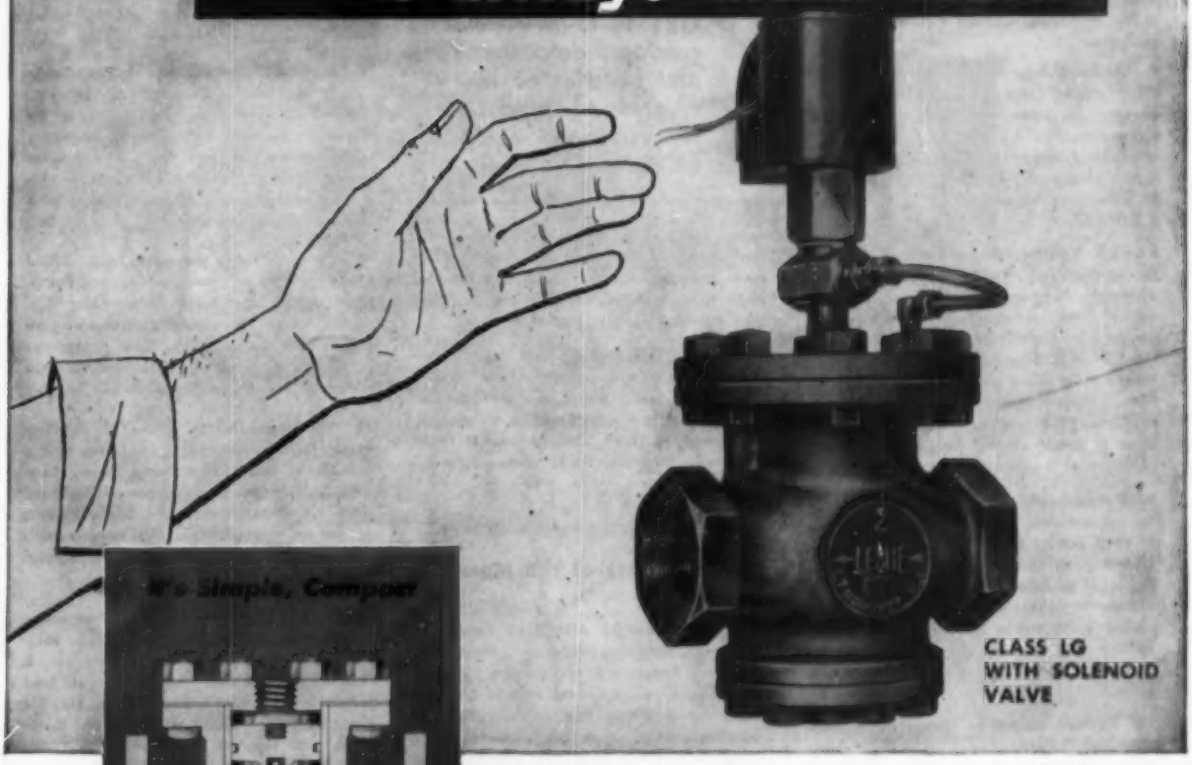
4 Control & Transfer Switches. General Electric's complete line of control & transfer switches is covered in a new 28-page bulletin. Applications to 600 v. a.c. or d.c. available. Book includes photos, drawings, cutaways & discussion of special features. Switches with water-tight & explosion-proof housings described. Also application data & representative contact diagrams.

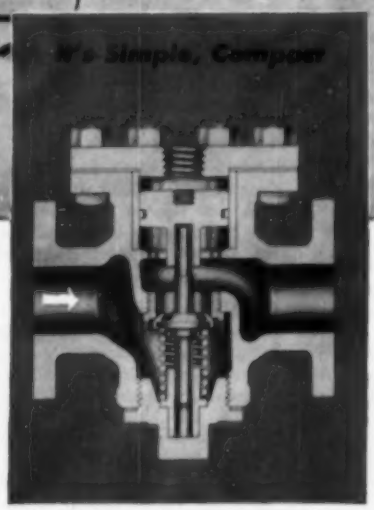
5 Dryers. Designed to dehydrate compressed air & other gases to a dew point of —50° F. or lower a line of dryers from Kahn & Co. Units alternate the compressed gas stream between twin adsorption towers, one dehydrating the gas while the adsorbent in the other is being reactivated thus assuring continuous drying action. Illustrated booklet available.

6 Drum Lift. A new, improved unit from Sterling, Fleischman Co. enables one man to handle steel drums (55 & 30 gal.), fibre drums (18 to 23 in. diam.), & acid carboys (13 gal.). For use wherever drums are handled. Capacity 750 lb. Lifting

(Continued on page 74)

This operating valve is *always* within *reach*





Simplicity and compactness keep cost *down*, reliability *up* in this Leslie Class LP operating valve.

Make a demand — the valve obeys. It's like having a third hand and a long arm as the control for this shut-off valve is *always* within *reach*.

You can get Leslie shut-off valves equipped with an electric solenoid valve (Class LG) or you can operate them remotely (LP) with air or hydraulic relay valve. Valve opens and closes on demand of a manual or automatic signalling device (pressure switch, thermostat, etc.)

Designed for off-on service, there are units with body ratings to 1,000 psi and temperatures to 750°F. The valves give fast, tight shutoff of steam, air and non-corrosive fluids.

Ask your Leslie engineer to help you select the operating valve that's engineered to meet your service requirements. You'll find him listed under "Valves" or "Regulators" in your classified telephone directory.

Bulletin 5309 describes operating valves.
Send for it today.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 241 GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

equipment-

(Continued from page 72)

power supplied by foot-operated hydraulic jack. Drums can be raised for pouring to height of 53 in. May be stacked two high vertically.

7 Check Valve. A simplified flanged silent check valve for control of water hammer has been developed by Williams Gauge Co., Inc. May be used for all types of hot or cold liquid service including water, oils, acids, chemicals etc. Available in sizes 1 to 10 in., for pressures 125 to 2,500 lb.

8 High Voltage Electron-Beam Processing. A 3-million-volt Van de Graaff particle accelerator a powerful machine radiation source now commercially available, announced by High Voltage Engineering Corp. This 9-ton supervoltage generator is designed to produce most fundamental radiations. Conversion of machine from production of one type radiation to another is simple step. Rating is 3,000 watts radiation at 3-million volts.

9 Electro-Caloric Flowmeter. Instrument to indicate rate of flow & totalized flow of most liquids and gases, said to be revolutionary in that rate of heat transfer through boundary layer of a fluid is utilized to obtain flow measurement. Such varied materials as gasoline, HCl, juices, paper pulp, & blood plasma may be measured. Industrial Development Laboratories.

10 Rupture Assembly. Designed to meet chemical industry demand for dependable foolproof rupture disc assembly for which replacement discs are easily available. Basic principle employs flat disc operating against characterized backup ring. Radius of ring is such that disc metal will flow tangentially under pressure & not shear. Principle guarantees reproducible bursts plus flowering action of disc when it fails. Pressure Products Industries, Inc.

11 Gridsteel Contour Retainer. Armor Grid. Damage to vessel walls from catalytic bombardment may be controlled with Gridsteel Contour Retainer Mesh, a new low-cost steel mesh retainer & armor manufactured by Irving Subway Grating Co. Used for interiors of catalytic regenerators, reactors, gas stacks, etc. Mesh is made of steel bars on edge fastened in overall hexagonal pattern. Standard panels 3 x 10 ft. Also available in type 430 stainless steel.

12 Plastic Pipe. Called Rivicior, new rigid pipe extruded of special high-strength polyvinyl chloride compound from American Hard Rubber Co. Offers unusual combination of chemical resistance, high bursting strength & toughness. Being unplasticized PVC material is resistant to most chemicals, including many troublesome organics.

14 Barometric Condensers. Removal of air, exhaust steam, & other vapors from vacuum equipment by use of Schutte and Koerting Co. barometric condensers is subject of their new bulletin. Covers condenser theory, basic types & styles, application & construction information, plus operation.

15 Filters. Called Hydra-Shoc this tubular filter is useful for any water or chemical purification task. Builds up air pressure at end of cycle & uses pressure for sudden back-surge to clean filter. Industrial Filter and Pump Mfg. Co. Folder shows cutaway view.

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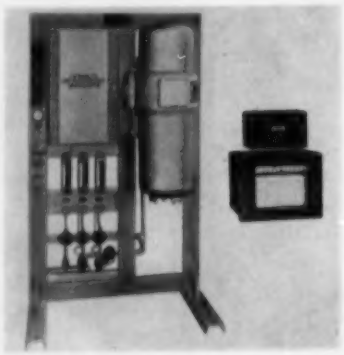
Developments of the Month (Continued)

91 WATER VAPOR ANALYZER developed by Mine Safety Appliances Co., Pittsburgh, and Esso Research & Engineering Co. provides continuous, automatic method & instrument for recording low concentrations of water vapor in air or gas streams, solves moisture problems in process industries and gas pipe lines. Operating on 4-minute measuring cycles, the new method has been used in instruments with a full scale range of 100 ppm water by volume and would appear to operate satisfactorily with even lower full scale ranges. Sensitivity of 1.25 ppm by volume has been attained, accuracy is limited by noise level and calibration errors to about 1 ppm.



MSA water vapor analyzer—a complete thermoelectric instrument for measuring and recording low concentrations of water vapor continuously in air or gas streams.

(Continued on page 76)

16 Dryers. Introduced by Hardinge Co., Inc. a selection of self-contained pilot plant or laboratory size Ruggles-Coles rotary dryers available in three models. Extremely compact, units require only fuel & electrical connections to be placed in operation. Easily moved from one place to another. Bulletins AH-471, AH-472, AH-473 cover three types.

17 Inert Gas Generators. Roots-Connersville Blower Div. of Dresser Industries, Inc. has just released a booklet of interest to those considering such equipment or means of protection against fire & explosion hazards. Includes detailed drawings, photographs, capacity & dimension tables, plus a novel information sheet.

18 Metering Pump Accuracy Tests. Titled "Fundamentals of Controlled Volume Pumping," a booklet from Milton Roy Co. Covers factors governing accuracy in controlled volume pumping. Test procedures & results of separate investigations into metering accuracy are recorded.

19 Verticlosed Motor. From U. S. Electrical Motors, Inc. a Verticlosed motor bulletin on this turbine pump motor. Contains 66 full-colored illustrations & technical drawings depicting features & applications of various types. Sizes 1½ to 400 h.p.; single-phase designs to 7½ h.p.; totally-enclosed types to 150 h.p.

20 Motor Base. A new & inexpensive motor base for V-belt drives which automatically compensates for belt stress & maintains exact belt tensions for all load conditions is available from Lovejoy Flexible Coupling Co. Called Auto-Tension Motor Base, unit requires no maintenance. Belts may be changed without disturbing mounting. Operation is quiet. Frame sizes 1/6 to 7½ h.p.

21 Belt Conveyor Tripper. A new unit accommodating long center roll, deep-troughing idlers developed by Stephens-Adamson Mfg. Co. is available for use with belt conveyors handling light materials such as grain, wood chips, & similar materials. Changing drive mechanism from shaft to chain transmission tripper not only clears 45° & 35° grain-type idlers but keeps headroom requirements to minimum.

22 Heated Gages & Valves. To meet the demand for heated gages & valves where steam is unavailable Jerguson Gage & Valve Co. announce development of an electrically heated unit. Applicable to problems involving heating of cold liquids such as waxes, etc., or in cold weather for prevention of gage freezing & breakage.

23 Weather-Protected Motors. From Allis-Chalmers Mfg. Co. a bulletin on weather-protected motors for outdoor installation. Units are available in all commonly used ratings, both horizontal & vertical, 250 h.p. & above. Mechanical features illustrated by cross section diagram.

(Continued on page 76)

THIS VALVE GOES TO SCHOOL!

In spite of our belief that the Cooper Alloy stainless steel valve offers the best in design and operating features, we take it to school regularly. This "school" consists of continual study by field engineers observing the valve in service, by design engineers alert for new materials and construction methods, and by industry itself subjecting it to intensive examination and reporting their findings at organized Valve Clinics.

Cooper Alloy Area Valve Clinics have been held in most major industrial centers, and our in-plant clinics have been held on the spot in dozens of leading plants, including Dow, DuPont, Mathieson, Celanese, Pfizer and many others. At these meetings our staff presents its findings, listens to the findings of users, specifiers and buyers, and attempts to work out specific problems.

Arrangements for such a clinic in your own plant may be made through our Public Relations Division.

"75 Questions". . . a selection of those questions asked most often at our clinics, is available on request.

Valve & Fitting Division

COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

equipment-

(Continued from page 74)

24 Centrifugation Problems. A new & practical aid to solution of centrifugation problems by means of proper selection of equipment is the subject of a booklet from Centrico Inc. distributors of Westfalia AG centrifugal separators. Explains basic separation principles, & presents list of applications. Gives correct type to be used in each category.

25 Canned Motor Pumps. A new illustrated bulletin from Chempump Corp. describes construction & operation of their high temperature Series T canned motor Chempumps. Units are leakproof for pumping fluids such as Dowtherm Arochlor, Para-Cymene & others at 1,000° F.

26 Infrared Spectrophotometer. Perkin-Elmer Corp. makes available a new brochure demonstrating the performance capabilities of their Model 21 Double Beam Infrared Spectrophotometer in various spectral regions.

27 Heat Transfer Bulletin. Recently issued by Downingtown Iron Works, Inc. a heat transfer bulletin which contains a table of heat transfer rates for various duties, tube sheet layout tables & a sample calculating sheet. Also illustrates & describes various types designed & built by them. A second bulletin describes their facilities for fabricating various types of equipment.

28 Compressors. An illustrated engineering catalog describing the new Type FMP compressor available from Cooper-Bessemer Corp. This reciprocating unit is built for field pickup service, gas boosting, air drilling & general industrial use. Ratings to 600 h.p. as belt-driven or "packaged" unit.

29 Heat Exchanger. A loose-leaf binder insert bulletin from Griscom-Russell on the many-purpose heat exchanger designated as G-R Twin G-Fin Section. Developed years ago now claims 70,000 units installed on heating, cooling, condensing & heat exchange service of many kinds. Outlines applications, etc.

30 Rotary Displacement Pump. Descriptive & engineering data covering Eco Engineering Co. All-Chem unit for corrosive & hazardous fluids, contained in binder insert folder. Designed for chemical handling, pump is available in several corrosion resistant alloy combinations with inert nonmetallic impellers, seals & packing. Various drive combinations adapt pump to conventional or special applications.

31 Flush-Feeder. High concentration slurry solutions & corrosive liquids may be effectively handled by a simple flush-feeder developed by Proportioneers, Inc. Its ability to pump slurries of thin mud-like consistency permit use of small makeup tank which holds sufficient slurry for several days of operation, minimizing operator surveillance & reducing operational costs.

32 Cooling Towers. Called Flow-Mizer are new cooling towers developed by Acme Industries, Inc. Features include stepped-up capacities & increased efficiency through incorporation of advanced-design Acme-Pak, consisting of a series of vertically mounted steel plates which create ideal conditions for water evaporation & fast, efficient heat dissipation.

33 Chlorine Gas Feeder. A multi-colored bulletin from Builders-Providence, Inc. on a high-capacity volumetric chlorine gas feeder said accurately to control & meter chlorine gas under vacuum to produce & deliver chlorine-water solution to the point of application at rates to 8,000 lb./24 hr. maximum with standard meter range of 1 to 10. Sections on operation, safety features & control variations, plus illustrations & flow diagrams.

34 Potentiometer. The new Type K-3 Universal Potentiometer developed by Leeds & Northrup Co. centralizes three or four dial readings into one single row of digits plus a scale value. Other features are guarding of instrument circuit against static, leakages & effects of high humidity. Instrument is housed in metal case & is available for either bench- or relay rack type mounting.

35 Moisture Measurement Bulletin. How to measure water vapor in air & other gases is the subject of an informative bulletin released by Pittsburgh Lectrodryer Corp. Discusses gravometric, dew point & wet & dry bulb methods. Also some less used & experimental schemes.

36 Rubber Linings. A new catalog of corrosion, abrasion, & contamination resistant rubber linings for tanks, pipe, valves, & similar storage & process equipment issued by Raybestos-Manhattan, Inc. Well illustrated it contains useful charts, tables & diagrams, with specifications & suggestions.

37 Size Classification Equipment. A new series of bulletin on the Richmond line of sifters now available from Sprout, Waldron & Co., Inc. Flow diagrams, dimensional sketches & specification tables are featured on sifters ranging from laboratory size to high capacity machines weighing up to 30 sieve & capable of making up to eight separations. Manufacturer maintains engineering & advisory office for customer service.

38 Electronic Instruments. A well-illustrated bulletin from Bristol Co. covers their line of electronic instruments. Divided into three sections one gives details of instrument & its components in addition to operating principles. Second section lists sensing elements & special attachments, & the third equipment made by others but which has Dynamasters incorporated, including strain gages & the like.

39 Control Valves. Ratogate control valves the product of Fischer & Porter Co. are now available with interchangeable restricted port openings for varying service conditions. Insertion of restricted port does not affect the length of the valve stroke or uniform flow characteristics. Thus a single valve can be used to control flow accurately over a wide flow range.

40 Space Filter. Development of a noncombustible glass fiber web filter media provides initial filtration efficiency of 99.97% for the newest Mine Safety Appliance Co. Ultra-Aire space filter. This unit is used in hospitals, research laboratories, as well as nuclear energy; pharmaceutical & other product control & processing industries where exceptionally clean air is required. Glass fiber web—93% glass & 7% binder—will not burn.

(Continued on page 78)

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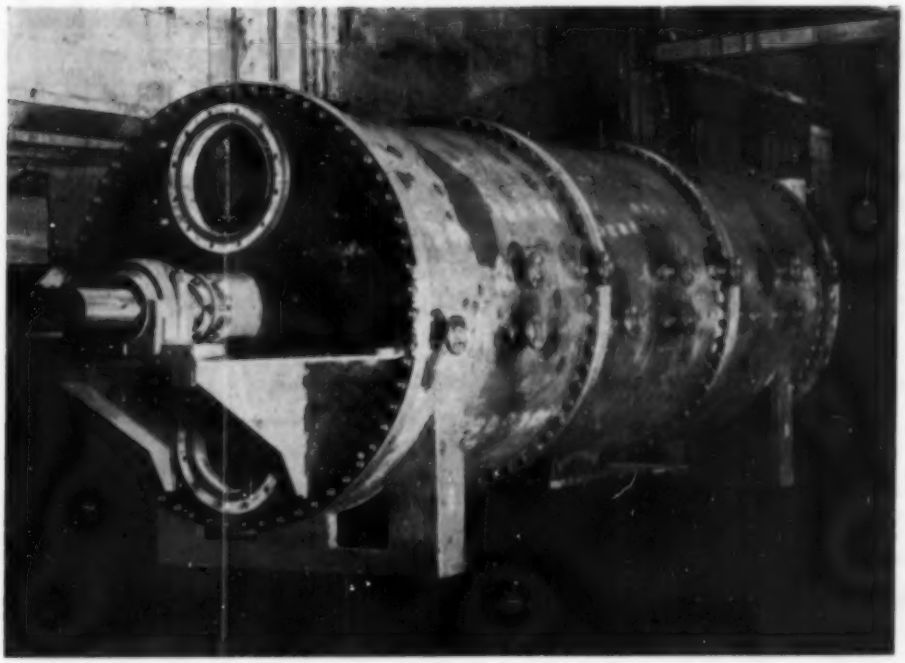
Three-part Impervite Cross-Bore heat exchanger: 1) one-piece, fully floating heat transfer cylinder, 2) one-piece header domes, and 3) shell with required nozzles and mounting brackets.

Developments of the Month *(Continued)*

92 IMPERVIOUS GRAPHITE HEAT EXCHANGER sold under trade name "Cross-Bore" by Falls Industries is claimed to have three major advantages over standard tube and shell design: 1) accommodates operating pressures in the 150-200 psi range, more than twice that possible with impervious graphite tube and shell exchangers; 2) unusually good resistance to physical shock, both internal (steam hammer) and external; and 3) all passages for both fluids handled can be easily, quickly and thoroughly cleaned by removing the one-piece heat transfer cylinder from the shell.

(Continued on page 78)



5' Dia. x 16' Long Horizontal Dryer with spring loaded scraper agitators in place

HORIZONTAL PROCESSING
by Bethlehem

Horizontal Processing Offers These Solutions to Processing Problems:

- Continuous or Semi-continuous Operation
- Processing of High Consistency Materials
- High Heat Transfer Rate, Vigorous Mixing, and Intense Shearing
- Reasonable Power Input for Agitation
- Exposure and Renewal of Surface

For Difficult Operations Such As:

- Evaporation of Water and Solvents from Slurries, Sludges and Pastes
- Reaction Between Gases, Solids or Materials of High Consistency
- Drying of Solids
- Continuous Production of Such Products as Formic Acid and Gypsum

Agitator assembly

Bethlehem Horizontal Dryer For Sludge Operates Semi-Continously

Horizontal, mechanically agitated dryer evaporates organic liquid from ore sludge.

Thermocoil construction (cast iron with cast-in steel coils) for shell is especially useful for circulating liquid heat transfer such as molten salt or Dowtherm. Cast iron shell, machined inside, provides an even, non-galling surface for scraper agitators. Fabricated agitators of abrasion resistant steel are specially designed for obtaining high heat transfer despite caking effect of sludge drying at the wall. Agitators and entire unit constructed for ease of maintenance. Unit is self-discharging.

Call on Bethlehem's years of experience in designing and building processing equipment to solve your horizontal processing application. We have designs which may be easily adapted to your process, or we can design units tailored to fit your process.

For complete details call in one of our engineers.

1856 BETHLEHEM 1956
One Hundredth Anniversary

BETHLEHEM FOUNDRY & MACHINE CO.
Process Equipment Division
BETHLEHEM PENNSYLVANIA

equipment-

(Continued from page 76)

41 Slide Valves. Data sheet Ub from Allen-Sherman-Hoff Co. describes their line of Universal slide valves designed for use in pipeline transporting solid materials in liquids. Line diagrams with dimension tables give pertinent size data for various models.

42 Air Wash Systems. The development of a line of ARco rubber lined, acid-proof air washers announced by Automotive Rubber Co., Inc. Said to be capable of eliminating 90 to 99% toxic fumes & corrosives from exhaust gases. Acid-proof washers are equipped optionally with straight-through air inlet & discharge; with end inlet & end discharge & added downstream access hatch. Capacities 7,200 to 57,600 cu.ft./min.

43 Centrifugal Pump. Said to accommodate fluctuating volume & head a new centrifugal pump from Gardner-Denver Co. In each size this new pump designated model BL handles wider than usual range of pressures & capacities, & will accommodate fluctuations in either pressure or capacity without serious loss of efficiency.

44 Vibratory Feeder. Said to challenge all existing standards of efficiency is a new type vibratory feeder from Eriez Mfg. Co. Called HI-VI Electro-Permanent Magnetic Vibratory Feeder unit operates directly on available 115 or 230 volt a.c. without rectifier. The simple electro-permanent magnetic drive delivers higher vibratory output with lower input & eliminates need for bearings & friction-producing parts. Adaptable to varied materials & operations.

45 Atmosphere Analyzer. Used to monitor air pollutants is an atmosphere analyzer manufactured by Harold Kruger Instruments. It detects & continuously records low concentrations of oxidants, nitrogen dioxide, nitric oxide & sulfur dioxide present. Features sensitivity, high speed response & versatility. Detects & records concentrations below 1 p.p.m.

46 Dissolvers & Blending Machines. Improved types of these units have been added to the line of process equipment manufactured by Dravo Corp. Unit LMU-50 has a working capacity of 1,800 gal. Made of heavy steel, dissolving chamber is a vertical type jacketed & baffled tank for positive circulation of brine at 50 lb./sq.in. working pressure. Turbine type agitator is equipped with mechanical shaft seal.

47 Gas Alarm System. A completely self-portable analyzer for use in or near hazardous locations available from Davis Instruments. Features visual & audible "high gas" signals, continuous sampling, large visible meter calibrated 0 to lower explosive limit. Operates on 110 v. 60 cycle, single phase, 100 w.

48 Heat Exchanger. Called Polybloc, a graphite heat exchanger said to be new, unique, patented, & corrosion resistant. Folder shows cutaway view in color. Minimum space requirement. Carbone Corp.

49 Ultrasonic Equipment. Added to line of Alcar Instruments, Inc. the Inspectogage an ultrasonic resonance measuring device which gives visual indication of the thickness of material, rapidly & accurately, from one side of the work. Ranges .025 to 0.50 up to .150 to .300. Illustrated leaflet gives additional information.

50 Magnesium Anodes. A bulletin from Federated Metals Div. of American Smelting and Refining Co. gives details of size, weight & attachment fittings for magnesium anodes used to protect against sea water galvanic corrosion. Show illustration plus three-view, dimensioned line drawings for each of 16 different sizes & shapes of magnesium anodes in line.

51 Pyrometer. A Hand-Held Probe Pyrometer is announced by Pacific Transducer Corp. for use in all types of non-corrosive metallic & non-metallic liquids, & in atmospheres of furnaces, kilns, & other high heat containers. Features lightness & extreme portability. Has a calibrating thermometer built in. Chromelalumel couple has range of 2,300° F. (1,300° C.), & iron constantan couple has range of 1,600° F. (800° C.).

52 Analyzers & Recorders. A bulletin containing photos of different types of Hays Corp. chemically operated CO_2 analyzers & recorders contains descriptions of operation & sampling system accompanied by drawings. Also covers application, principle, features, models & standard charts.

53 Rectification Plants. Single & double rectification plants for production of oxygen or nitrogen in gaseous or liquid form are subject of catalog from Superior Air Products Co. Also illustrates liquid air & acetylene plants.

DEVELOPMENTS of the month (Cont.)

93 SELECTION OF CONDENSER TUBE ALLOYS may be simplified through 44-page manual available from American Brass Co. Booklet discusses the application and installation of condenser and heat-exchanger tubes, plates for tube sheets, heads and baffles. Designed for engineers responsible for selection of material in marine, oil refinery and stationary steam power plant industries, gives detailed information plant industries, gives detailed information laboratory tests.

ANACONDA
TUBES and PLATES
For Condensers and Heat Exchangers
THE AMERICAN BRASS CO.

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materials-

80 Laminated Tape Coating. A system which revolutionizes pipeline corrosion protection. All priming adhesives & butyl-rubber tapes in line have copper-8-quinolinolate. Sure protection against attack by fungus & bacteria. Available in six colors plus black & white. Bulletin. Plicoflex, Inc.

81 Anhydrides. A new booklet from Carbide & Carbon Chemicals Co. on anhydrides. Suggests uses, physical properties, specifications, plus constant boiling mixtures for materials offered by Carbide. Used in manufacture of textile fibers, plastics, pharmaceuticals, etc. anhydrides are extremely reactive chemical intermediates.

82 Lithium Bibliography. Publication of Supplement No. 4 of the Annotated Bibliography on "The Use of Organolithium Compounds in Organic Synthesis," offered by Lithium Corp. Useful as a reference work & guide to research on lithium & its compounds.

83 Hydrogen Peroxide. Properties, uses & handling of hydrogen peroxide are the subject of new booklet offered by Solvay Process Div. Illustrated with tables & diagrams, text covers some reactions of material as bleaching agent in textile & paper industries, in chemical syntheses, as a polymerization catalyst, & other uses. Describes storage, safe handling, unloading in various containers.

84 QO Tetrahydrofurfuryl Alcohol. Available from the Chemicals Dept., Quaker Oats Co. binder insert booklet divided into 5 main sections including general information, physical data, chemistry, uses, & safety. Eight pages of charts & tables.

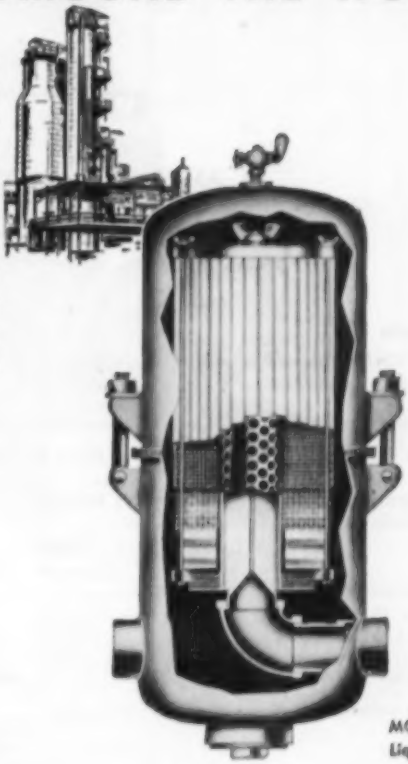
85 Titanium. New bulletin from Mallory-Sharon Titanium Corp. gives available data on corrosion resistance of titanium, suggests to product designer where metal may be applied to overcome corrosion problems. Uses, based on corrosion resistance are described. Lists corrosion ratings for metal when exposed to common types of corrosive agents.

VERSATILE STAYNEW LIQUID FILTERS

For Oils, Water, Chemicals, Coolants

SOLVE FILTERING PROBLEMS AROUND THE WORLD

PRACTICALLY any liquid can be efficiently and economically filtered by a Staynew Liquid Filter. They are designed for adaptation to virtually any space requirement or any arrangement of inlet and outlet connections. All known types of filtering media are available to provide any degree of efficiency for any specific problem, or for use regardless of temperature, pressure or corrosion requirement. All units can be constructed according to the API-ASME and the various ASME Code specifications. Staynew Model ELS liquid filters are available in many types of materials other than regular steel, such as stainless steel, monel, herculoy and other non-corrosive materials.



MODEL ELS
Liquid Filter

PARTIAL LIST OF LIQUIDS THAT CAN BE FILTERED BY STAYNEW LIQUID FILTERS

Acetone
Acids
Adhesives
Alcohols
Alkalis
Ammonia
Asphalt
Benzene
Benzine
Beverages
Butane
Casein
Castor Oil
Caustic
Cellulose Solutions
Chlorine
Chocolate
Cleaning Fluids
Coating
Coolants
Cutting Oils
Emulsions
Enamels
Ethanolamine
Ethylamine
Extracts
Flameproofing Solutions
Fuel Oil
Furniture Polish
Gasoline
Glue
Greases
Gums
Hydraulic Fluids
Ink
Kerosene
Lacquers
Latex
Liquid Paraffin
Lubricants
Molasses
Naphtha
Paint
Pharmaceuticals
Propylene
Quenching Oils
Resins
Rubber Cements
Sizing
Soap
Solvents
Steam Condensate
Syrups
Tar
Turpentine
Varnish
Vegetable Oils
Viscose
Water
Wax

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AUDITOR'S REPORT

We have examined the balance sheet of the American Institute of Chemical Engineers as of December 31, 1955 and the related statement of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statement of income and surplus present fairly the financial position of the American Institute of Chemical Engineers at December 31, 1955, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

F. W. LAFRENTZ & CO.
Certified Public Accountants

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

BALANCE SHEET

DECEMBER 31, 1955

Assets

Current assets:		
Cash on hand and demand deposits	$149,293.19	
Cash in savings institutions	112,893.05	
Total	$262,186.24	
Less cash in research and Bowman funds	52,604.38	$209,581.86
Investments, at cost including accrued interest	$ 74,035.22	
Less investments in Marshall and Bowman funds	4,000.00	70,035.22
Accounts receivable, net		63,607.41
Inventory, at cost		12,520.43
Prepaid expenses		598.12
Total current assets		$356,343.04
Deposits at airlines, post office, etc.		1,900.75
Total		$358,243.79
Trust and Special Funds:		
Albert E. Marshall fund	$ 3,000.00	
Frederic C. Bowman fund	1,088.04	
Research Committee fund	52,516.34	
	$56,604.38	56,604.38
Total		$414,848.17

Liabilities

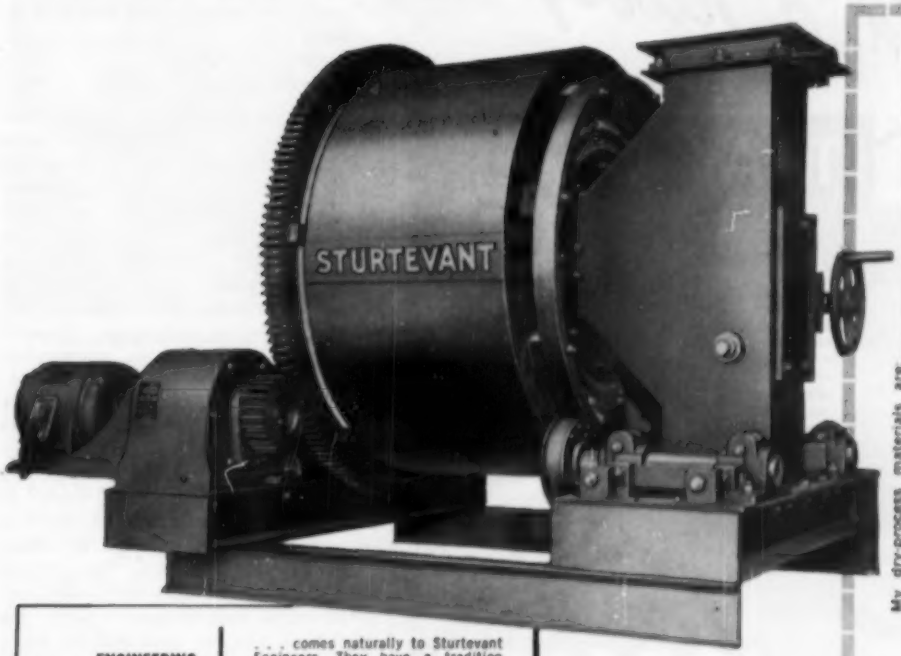
Current Liabilities:		
Accounts payable		$ 28,403.72
Deferred income		145,080.78
Education and preprint funds		5,161.18
Surplus		179,598.11
Total		$358,243.79
Trust and special funds (as set forth above)		56,604.38
Total		$414,848.17

STATEMENT OF INCOME AND SURPLUS

FOR THE YEAR ENDED DECEMBER 31, 1955

Income:		
Membership dues	$212,366.65	
Less allocation to subscriptions	64,708.12	$147,658.53
Membership entrance fees		11,092.00
Publications		415,446.14
Nuclear Engineering Congress and Atomic Exposition		16,322.24
Meetings		5,644.88
Investment		5,084.68
Sundry		329.44
Total		$601,577.91
Expenses:		
Publications		$217,182.86
Salaries and commission		255,176.00
Employees' retirement plan		4,295.29
Federal insurance contributions		3,555.28
Rent and electric		18,253.52
Office equipment		6,904.23
Postage, telephone & telegraph, auditing and insurance		20,641.43
Printing, stationery and supplies		16,286.99
Membership directory and meetings programs		8,901.74
Travel		4,825.11
Participation in professional groups		3,833.00
Committees		3,236.78
Awards		1,340.38
Special Task Committee—Engineering center		15,000.00
Miscellaneous		5,889.16
Total		$585,321.77
Net income for year		$ 16,256.14
Surplus, December 31, 1954	$164,401.49	
Less Frederic C. Bowman legacy of $1,000.00 received 12/17/52 and the income to 12/31/54 of $59.52, now recorded as a specific fund	1,059.52	163,341.97
Surplus, December 31, 1955		$179,598.11

COSTS OF BETTER BLENDS CUT TWO TESTED WAYS



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RESEARCH COSTS

(*Continued from page 64*)

methods of control will essentially suggest themselves.

The people in a research organization can be divided into four groups as follows:

a. technically trained people working directly on research projects
b. nontechnical people working directly on research projects
c. supervisory personnel
d. supporting personnel

Some manufacturing companies have established the concept that there exists within the organization a group of people who constitute the productive unit. Each person in this unit contributes directly to the production of something. All other people in the organization are there only to assist the productive worker in his job of producing something. Reduced to a simple example, an independent plumber and his helper may be considered an organization. The plumber is the productive worker and his helper is there only to assist him. The plumber will have only as many helpers as will enable him to produce more work. If his business grows enough, he may hire several other plumbers each of whom has one or more helpers. The original plumber has now become a boss and he no longer does productive work. He may work just as hard and he probably will spend more hours per day at his job, but the amount of productive work is still measured by the number of plumbers, the assumption being that each plumber does a reasonable day's work.

This concept is applicable also to research. In a research organization the productive worker is the technically trained man working directly on a research project. He is the man primarily responsible for the success or failure of his project. Good supervision can help him to understand how his project fits into the over-all picture. Helpers can relieve him of routine work, thereby permitting him to spend more time on the technical aspects of his projects. But the supervisor would not be there unless the technical man had a job to do. And a good technical man will use only as many helpers as will permit him to increase his technical activities. The category of helpers includes technicians, who may be working directly on research projects, as well as such supporting personnel as craftsmen, clerks, stenographers, etc.

This suggests that the key point of control in a research organization can be the number of technical men who

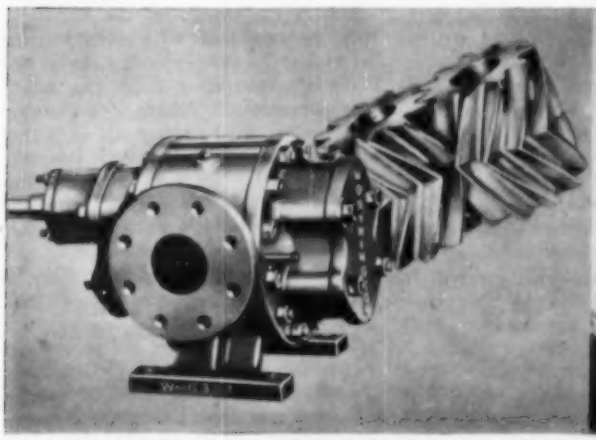
(*Continued on page 84*)

WHAT'S YOUR P.Q.?*

*PUMP QUOTIENT

Pump standardization—how do you benefit? By standardizing, you can often drastically cut your spare parts inventory. With Worthington's SESC (Standard End Suction Centrifugal) line, you are also assured of immediate delivery from factory or distributor stocks. Because the SESC line consists of standardized "parts" not "pumps," it can be built in many different combinations . . . 70,480 to be exact. For all these reasons, more and more companies are turning to SESC pumps. See bulletin W-300-B4.

Packed stuffing box or mechanical seal—which is preferred? Each has its applications. Mechanical seals are gaining in popularity year after year. With Worthington's Standard End Suction Centrifugal pumps you not only get your choice of mechanical seals—or packing—but you can easily convert from one to the other using standard stock parts. This "interchangeability" is just one of the many extra advantages of Worthington's SESC line. For more details write for bulletins W-300-B4 and W-350-B16.



Which pump is best for difficult suction conditions? Worthington's close-clearance rotary pump is self-priming and can operate under vacuums as high as 28 inches of mercury. The large unobstructed suction opening in this herringbone gear pump permits operation with thin or viscous liquids at high efficiency. The double-helical gears balance all end thrust, eliminate trapping of liquid between gear teeth and provide a quiet, pulsation-free flow at high speeds. For the full story, ask for bulletin W-483-B2.

Whose pumps would you expect to find in the Eiffel Tower? If you said "Worthington's," your P.Q. is all right. The original steam-driven pumps that power the Eiffel Tower's 100-passenger hydraulic elevators were built by Worthington back in 1889. The most recent additions, modern electric-drive Worthington pumps, moved into the Tower just last year. Today as then, wherever men must move liquid, they turn to the company with a reputation for performance. Worthington Corp., Harrison, N. J. PC-6.5

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RESEARCH COSTS

(*Continued from page 82*)

are working on technical projects. The rest of the organization can be related to this number. The cost of supervisory and supporting personnel, supplies, overhead, and equipment (except possibly major capital items) can be divided by the number of technical people working directly on projects. This will give a series of figures which will tell the research director many things.

In a large research organization the costs of these items for every productive technical worker tend to become stabilized and then change only slowly unless the research management adopts a definite new policy which will force a change. In addition, costs expressed on this basis can be compared with costs in a similar organization provided that both organizations are using the same definitions to describe similar functions.

Once this method of cost accounting has been established, a number of cost control problems become considerably simplified. An example is here cited for an *average* research organization: The Bureau of Labor Statistics and the Research and Development Board determined by a survey that in 1951 the average cost of a research worker was $22,100 a year. This includes all costs of the research organizations surveyed. In other words, the costs of supplies, equipment, helpers, supporting personnel, and overhead, plus the salaries of the technical personnel were all added up and divided by the number of technical people. This means that it costs about $22,000 a year to keep a technical man in business.

It was stated previously that the first problem of the research director is to decide how much money he would like to spend during the coming year. It is usually fairly simple to decide how many technical men are needed for each project. If it is an *average* organization, the cost of each project will be $22,000 times the number of technical men working on that project. The *total* budget will be $22,000 times the total number of technical men on the staff. Of course, some projects will require more expensive equipment, special chemicals, etc., than others, but at least in a large organization, these things tend to become minor compared with the costs of overhead and other costs over which the research director has little or no control. Therefore, once the cost per technical man has been established the research director can proceed with considerable confidence to set up his budget in dollars solely on the basis of the number of technical men he needs.

This will immediately suggest that top management can place an effective and simple control on the research director by telling him how many technical men he may have on his staff at any given time. Within reasonable limits this will govern how much money the research director will spend. If he knows the average cost per technical man, he will have at his finger tips a convenient device for knowing how much he is spending on any given project. This will be much more satisfactory for control purposes than waiting for the accounting department to add up all the costs and submit a statement.

Profitability of Research Program, Rate of Return

At some point the research director will ask himself how much his organization is really contributing to the success of the company. If he fails to ask himself this question, he can rest assured that somebody else will. Unfortunately, again there is no simple answer.

A few research projects are sufficiently specific to permit calculating how much money will be made because of their existence. These projects will usually involve a new product. In such a case it is relatively simple to calculate the pay-off time on the estimated investment. If all research activity were in this field, the research director would have little trouble finding out whether his organization is contributing its fair share to the profits of the company. Entering new fields of activity and diversifying the company's business is undoubtedly interesting from the standpoint of research. There is a glamour surrounding the bringing out of a new product which may capture the imagination of the public and perhaps bring large profits relatively quickly. But the research director cannot depend on this to justify his department.

It has been suggested that there is a more important angle to research than developing new products—namely, research which is carried out purely and simply to keep the company in business. No company can stand still. No matter what the company or what the industry is there will be competitors, and they will be making progress regardless of others' success. A company has one or more products that form the backbone of its business. The research director must remember that this product, or these products, are the items which provide the money to keep him in business. He must always be sure that his products are at least as good as those of his competitors. Preferably they should be better, but if they are not as good as those offered by competition, the research director should start looking for another job because his company will not be in business very long.

The real problem of the research di-

(*Continued on page 88*)

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	DRL-1-1	DRL-1-2	DRL-1-3
SILICA (SiO_2)	.36%	.30%	.34%
IRON OXIDE (Fe_2O_3)	.072	.043	.049
ALUMINA (Al_2O_3)	.21	.20	.19
LIME (CaO)	55.00	54.90	55.40
MAGNESIA (MgO)	.65	.62	.51
SULPHUR (S)	.012	.011	.015
PHOSPHORUS (P)	.006	.006	.009
IGNITION LOSS	43.20	43.50	43.20
CALCIUM CARBONATE (Calculated)	97.90	97.72	98.51
MAGNESIUM CARBONATE (Calculated)	1.36	1.30	1.07

* Report prepared by Pittsburgh Testing Laboratories, Pittsburgh, Pa.

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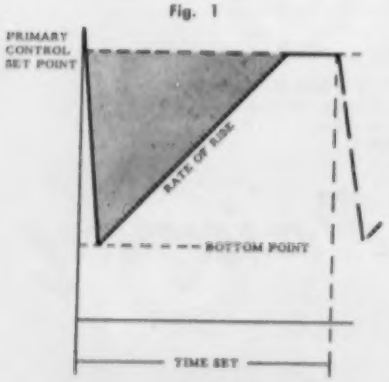
application of an ELECTRONIC CONTROL SYSTEM to a CHEMICAL PROCESSING PROBLEM

H. J. Ruston | Industrial Controls Division
Manning, Maxwell & Moore, Inc.
Stratford, Connecticut

One reason for the increasing popularity of electronic control systems is their ability to solve unusual process control problems. Their use of electrical circuitry, which can be altered almost at will, makes for greater ease of experimentation, and because various combinations and arrangements of vacuum tubes, capacitors, resistors, and other electrical components result in many different behaviors of the electrical signals, new horizons are opened for the solution of processing problems that have heretofore defied the instrument engineer.

Recently, an example of the unusual abilities of electronic systems came to light when a large chemical manufacturer developed a process which required cycling of the process pressure according to an accurate time schedule. Process pressure had to be dropped rapidly from a high value down to about a third of the range span, increased slowly back to the higher value, held there for a short time, and then dropped again. The rate of pressure rise had to be accurately controlled because too rapid increase would cause a secondary reaction which would be both dangerous and wasteful of product. At the same time, a slow rate of pressure rise would decelerate the reaction and cause a great loss of productivity. The chemical process engineers wanted to cycle the pressure at a rate close to the upper limit in order to improve productivity. This meant some sort of protective action would be required from the automatic controls should the secondary reaction begin to develop. The secondary reaction was signified by a rise in process temperature. The entire process reaction rate was regulated by a control valve in the pressure relief line of the process vessel.

Fig. 1



Such process performance qualifications created the following needs for the automatic controls:

A pressure program controller was required to carry out repeatedly the cycle shown in Figure 1. This was simple, but since the fastest permissible safe time was not known, the rate of rise curve and the total time per cycle (time set) had to be continuously adjustable as had the upper and lower pressure limits also. The instruments were required to repeat the cycle continuously until the reaction was completed. However, to protect the reaction and the security of the plant, it was necessary to decrease the rate of pressure rise should an increase in process temperature indicate a tendency toward the secondary reaction. This had to be done automatically. Furthermore, a rapidly increasing temperature should depress the pressure curve more than a slow increase.

This problem was presented to several instrument groups for solution. It was finally resolved by the electronic control system shown in Figure 2. A unique quality of this system was its handling of the problem with essentially standard components.

First the pressure programmer (Figure 2) made use of the fact that the output signal of an electronic controller remains *linear* throughout its range, so long as the input (error) signal remains constant. Thus, a proportional-plus-reset unit will put out a linearly increasing signal at any rate as set by a constant voltage supply. This output signal could be applied to a standard electronic pressure control system to set the control point across the scale at any desired rate. The actual rate could be varied by changing the supply voltage with a rheostat. The start of the pressure-rise cycle was triggered by an adjustable pressure switch, and the total cycle time varied by a conventional industrial timer. The upper pressure limit was adjusted by the mechanical set point of the pressure controller.

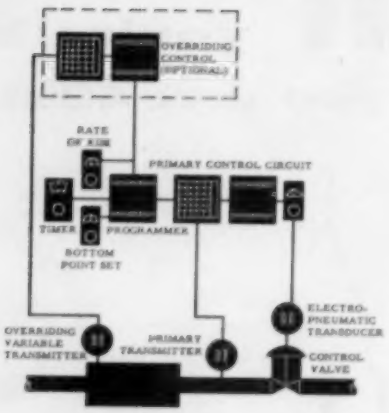


Fig. 2

Thus everything was taken care of except the temperature override action. A simple temperature control system feeding its control signal into the programmer was used. The controller incorporated such rate action that a rapid temperature rise would result in a greater signal output than would a low rate. This signal was fed to the programmer in order to oppose the signal from the voltage source. Thus, an increasing temperature signal would reduce the input to the programmer, which would result in a proportionally lower rate of pressure rise.

All the process requirements were thereby met by this control system. In operation, the system was found to be sufficiently sensitive and fast to hold to a minimum any danger from the secondary reaction. Pressure was held so closely to its program schedule that there was little need for the elaborate thermal override system. It was replaced by a simple electronic temperature relay that would slow the rate of pressure rise when temperature reached a dangerous value. This relay was able to simplify the equipment and still increase production by eliminating delays due to random thermal fluctuations.

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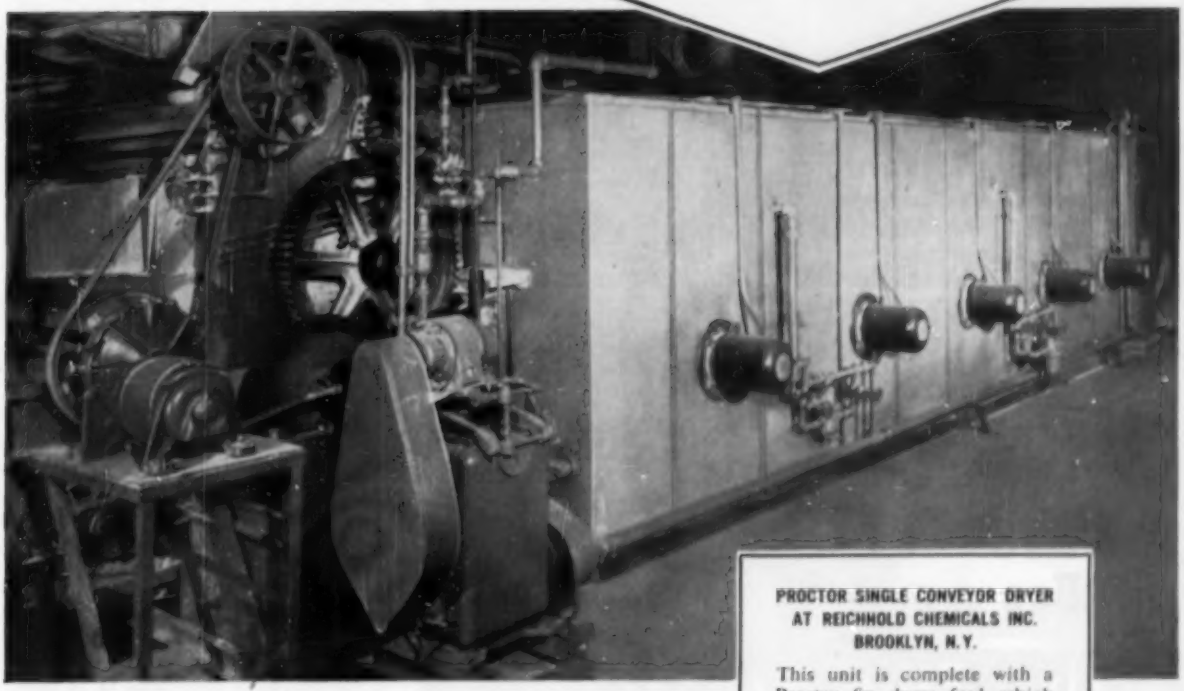

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RESEARCH COSTS

(Continued from page 84)

rector comes when he tries to justify research which is carried out just to keep the company in business. It is substantially impossible to calculate how much money the company would have lost if the last improvement in product quality had not been made. Likewise the research department can hardly claim all the profits from the increased business which followed the last improvement in product quality. In this case the sales department people will claim that all the increased business is due to their efforts. The manufacturing department will claim that the only reason for the increased business is operating efficiencies that they have achieved which permit a low selling price.

How, then, can the research director justify his existence? First of all he has to convince himself. Certainly he cannot hope to convince somebody else unless he has some basis for confidence in his own activities. There is no formula that can be used to justify the most important kind of research, that is, the research necessary to keep the company in business.

This suggests a deceptively simple answer to the research director's problem—one requiring a degree of judgment that some people just don't have. The successful research director must have a sort of sixth sense. He should have a feeling for what his competition is going to do. He knows that he cannot spend money in unlimited quantities, but rather must put certain sums of money where the best results will be obtained. In the field of research this kind of "judgment" is most important.

The only thing the research director can do is to look around at other companies in his field of activity. If they are growing faster than his own company, then he must take another look at his own long-range programs and policies, and make an objective analysis of his company's operation. If he finds that the company is growing at a satisfactory rate, that product quality has at least kept up with competition, and that an occasional new product has been brought out, chances are good that his organization is doing its part.

Literature Cited

1. Data on research as per cent of sales taken from "Industrial Research and Development—A Preliminary Report by Bureau of Labor Statistics, Department of Labor, and the Research and Development Board, Department of Defense. January, 1953."
2. Wilson, Robert E. Address before Industrial Research Institute, Chicago, Illinois (October 12, 1948).

AUTOMATION GOES TO WORK FOR VALVE MANUFACTURER

Unique "Transfer Machine" mass produces precision-machined valve bodies, employs many of the principles of automation for the first time in the valve industry.

At the Watertown, Mass., plant of Manning, Maxwell & Moore, the company's Hancock gate type high-pressure steel valves are now being manufactured on a unique "Transfer Machine," which is completely automatic and introduces many of the principles of automation into the valve industry.

Engineered and built by Baker Bros., Inc., Toledo, O., at a cost of over $250,000, the machine replaces six other machines of various types, requires only one operator, produces an average of 73 finished valve bodies per hour compared to 19 per hour by the old method.

The Transfer Machine with its single operator at the master control panel of the operation.

When the machine is fully loaded, 30 platens, each carrying a rough forging of a valve body, pass through a total of 26 stations. All chips are disposed of automatically, all units and moving parts are lubricated automatically. In all, the machine performs 10 drilling operations, 4 reaming, 6 tapping, 2 precision boring, 2 facing, 1 counterboring and 1 broaching. These occur simultaneously when the machine is cycled.

A new unit to increase chlorine production from 50 to 150 tons per day with accompanying increase of rayon grade caustic soda production, and probably an increase in caustic potash production, will be built at the Calvert City, Ky., chlor-caustic works of Pennsylvania Salt Mfg. Co. The expansion, part of Pennsalt's $55 million growth program, is expected to go into operation in 1957, will employ the newest type deNora cell under license from Monsanto. □

Now! VANTON offers three basic plastic lines to meet your varied pipe, fittings, valve requirements!

(P) PVC (Unplasticized, Unmodified, Polyvinyl Chloride)
For outstanding chemical resistance

(S) Styrene Copolymer
For exceptional impact strength

(N) Buna N (Acrylonitrile-Butadiene)
For excellent temperature resistance

Vanton, with many years of pioneering experience in the manufacture of plastic pumps, now makes available pipe, fittings and valves in the above basic materials. These plastic compounds have been selected to offer as broad a coverage as possible with respect to the application requirements of the process industry.

- ✓ Excellent corrosion resistance
- ✓ Non-contaminating properties
- ✓ Excellent mechanical performance
- ✓ Ease of installation
- ✓ Excellent electrical and insulating properties
- ✓ Economical
- ✓ High temperature resistance

THREE LINES OF PLASTIC PIPE VALVES FITTINGS

Write for Catalog PL 101

VPE

VANTON
PUMP & EQUIPMENT CORP.
division of Cooper Alloy Corporation HILLSIDE, N.J.

W & T CHLORINATION . . .

complete algae control for 25% of the cost of best previous treatment

The Geo. Wiedemann Brewing Co., of Newport, Kentucky had an algae problem on the water-side surfaces of their pasteurizers that increased operational costs, cut pasteurization efficiency, caused corrosive pitting of the units, and created very objectionable odors.

Five years ago, after trying other treatments, a Wallace & Tiernan chlorinator and proportioning solution panel were installed. The chlorination treatment has been completely successful in eliminating the problem at about one-fourth the cost of the best treatment tried previously.

A Wallace & Tiernan chlorination system can correct problems caused by algae growths in your process. Write for our free bulletin 2136-C that describes the Geo. Wiedemann Brewing Co. case history, and tell us of your specific problem.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
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W&T MERCHEN SCALE FEEDERS & METERS

for Automatic Batch Control
Continuous Blending
Materials Accounting

Control the feeding of ingredients by weight to an accuracy of 1%.
Capacities range from 3 to 3000 lbs. per min.

WRITE FOR YOUR COPY OF OUR BULLETIN:
"The Best Weigh is the Merchen Way."

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
M-31

ALL - ELECTRONIC INSTRUMENTATION FEATURES NEW ORGANIC REFINING PLANT

Truland Chemical will triple its refining capacity with new plant that makes it largest solvent refiner in U. S.

Ultra-modern new plant of Truland Chemical Co., a division of Trubek Laboratories, East Rutherford, N. J., is scheduled for completion this summer with initial refining operations to commence in August. Located at the parent company's site in East Rutherford, the new plant features up-to-date fractionating equipment with all-electronic instrumentation providing greater production economy and enabling the company to drastically reduce the cost of refining.

The new plant, like the present 100,000 gallon per month plant at Union, N. J., is designed to provide a complete distillation and refining service for the economical upgrading and disposal of organic by-products and residues derived from chemical processing, manufacturing and allied industries. As an example of the company's operations, from 1949 to 1951 it processed Jefferson Chemical's ethylene glycol still-bottoms into diethylene glycol and marketed the latter for Jefferson.

Ultra-modern refining plant of Truland will have electronic control, will triple production.

While Truland will continue to perform its complete custom refining of solvents and waste products on a toll basis, with the new plant just about ready to go on stream, the company is placing more emphasis on outright purchase of the starting material from chemical firms, producing and marketing the refined material itself.

For the expansion of methanol and petrochemical derivatives during the coming year, Commercial Solvents will spend $10 million. New construction will enlarge the Sterlington, La., methanol plant, and will also provide additional facilities at the Terre Haute, Ind., plant to process the company's basic products into upgraded chemical derivatives. □

Key unit in Spencer Chemical's polyethylene plant is the raw ethylene purification unit, located at the tower in the center of the picture, which has enabled the plant to operate without a captive source of ethylene, saving a multi-million dollar initial investment.

New facilities which will more than double Monsanto's capacity to produce vinyl chloride polymers and copolymers, have been placed in operation at the company's Plastics Division plant in Springfield, Mass. According to the company, national vinyl resin production should be 600 million pounds in 1956. □

After the fire at the Cranford, N. J., plant of Packing Engineering Corp., the company had a temporary delay in filling orders. Now in its new quarters, the company is back in full production and wishes to thank its customers for their cooperation and understanding. □

A million dollars will be invested in expansion and modernization of Stauffer Chemical's Niagara Falls, N. Y., plant. About 40% will be for additional 73% caustic soda facilities, about 15% for increased output of chlorinated solvents, and the remainder to improve present facilities producing chlorine, caustic, titanium tetrachloride, silicon tetrachloride and zirconium tetrachloride. □

Columbian Carbon Co.'s new office and laboratory center in Monroe, La., is expected to increase greatly the company's service potential to the chemical industry. Consisting of an office and engineering building, a rubber laboratory building, and a chemical laboratory building, the new facilities cost some $350,000. □

Substantially increased tonnages of sodium and potassium phosphates will be available to West Coast manufacturers when new facilities double production capacity at Westvaco's Newark, Calif., plant. Westvaco, a division of Food Machinery & Chemical, converts elemental phosphorus to phosphoric acid and a complete line of sodium and potassium phosphates at Newark.

TANTALUM... We recommend it only when it is the cheapest material AVAILABLE

Tantalum is seldom cheaper on a "per-pound" basis. But tantalum is quite often the "cheapest" material when judged on an over-all final operating cost basis, on a product purity basis, on a freedom from maintenance or an elimination of down-time basis.

We don't expect anyone to take tantalum on faith or generalities. But if you process hydrochloric acid, nitric acid, perchloric acid, bromine, iodine, hydrogen peroxide, sulfuric acid, chlorine, chlorine dioxide (and many other corrosives), tantalum may save you money. Fansteel engineers can tell you, definitely, whether or not tantalum will be "cheapest" for you.

USE TANTALUM WITH ECONOMY for most acid solutions and corrosive gases or vapors.

Not recommended for HF, strong alkalis or substances containing free SO_3.

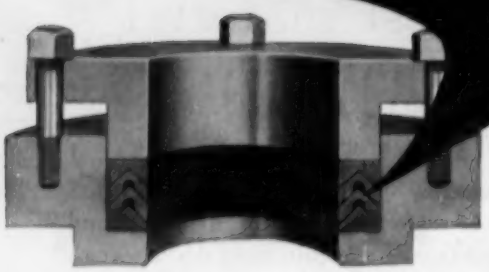
Write for free TANTALUM booklet today!

FANSTEEL METALLURGICAL CORPORATION
Chemical Equipment Division
NORTH CHICAGO, ILLINOIS, U.S.A.

G563A

ONE OF THE GARLOCK 2,000

SHALLOW STUFFING BOXES NEED THIS KIND OF "GRIP"



GARLOCK
431 CHEVRON* PACKING

tightens as pressure increases, eases off as pressure decreases, assuring no-leak sealing and minimum friction on rams, plungers, reciprocating rods, etc.

LOOK AT THESE SERVICE REPORTS:

- On hydraulic press with 40" dia. ram, operating at 6000 psi pressure, .006" clearance between ram and gland, GARLOCK 431 CHEVRON size 40" x 41½" by only 2" deep gave 14 years service.
- On hydraulically operated clutches with ¾" cylinder, 500 psi pressure, ¾" travel, operating intermittently. Neither leather cups nor "O" rings worked well. Now packed with GARLOCK 431 CHEVRON ⅜" x ¾" x 17/32" deep. Result: smooth, positive sealing.

And remember, 431 CHEVRON Packing is only one of "the famous GARLOCK 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet *all* your needs. It's the *only* complete line . . . it's one reason you get unbiased recommendations from your GARLOCK representative. Call him today or write for Folder AD-115.

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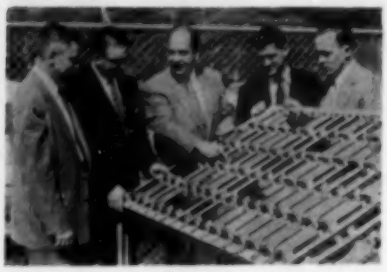
THE GARLOCK PACKING COMPANY,
Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

RESEARCH NEWS



A new bright nickel plating process called Levelume has been developed by Hanson-Van Winkle-Munning Co., is here being tested with plated panels exposed to outside weather and atmospheric conditions.

A novel research establishment is an "advance" research laboratory of Food Machinery & Chemical established on the Bronx campus of New York University, which will be moved in its entirety, people and equipment, to FMC's new research laboratories in Princeton as soon as they are completed. Meanwhile, a five-man research team from FMC has access to the NYU Engineering Division's library, faculty and staff members. □

New chemical applications, products, production processes and other technological advances in the Glidden Company's five major divisions were discussed and reviewed at Glidden's Eighth General Research Conference May 14-16. Under the leadership of W. von Fischer, newly appointed coordinator of research and development, and P. E. Sprague, Glidden vice president, the conference was attended by 60 scientists. □

The Fifth annual Glycerine Research Awards are now open, nomination blanks are available. Sponsored by the Glycerine Producers' Association, the awards are granted for independent research leading to new and improved applications of glycerine or glycerine derivatives to products or processes. First award is $1000 and an honor plaque, second award is $300, and third award is $200. □

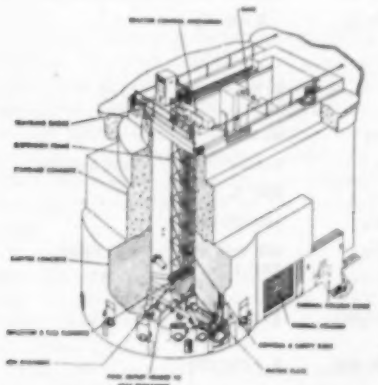
Recent Advances in Catalytic Polymerization will be the subject of a two-week special summer program at MIT from July 17 through July 27. The program is directed to active and potential research workers in polymerization and allied fields of chemistry and chemical engineering. It will present and discuss current knowledge of catalytic polymerization.

A. A. Morton will direct the program. Lecturer will include W. H. Stockmayer, E. J. Lanpher, and several guest speakers. □

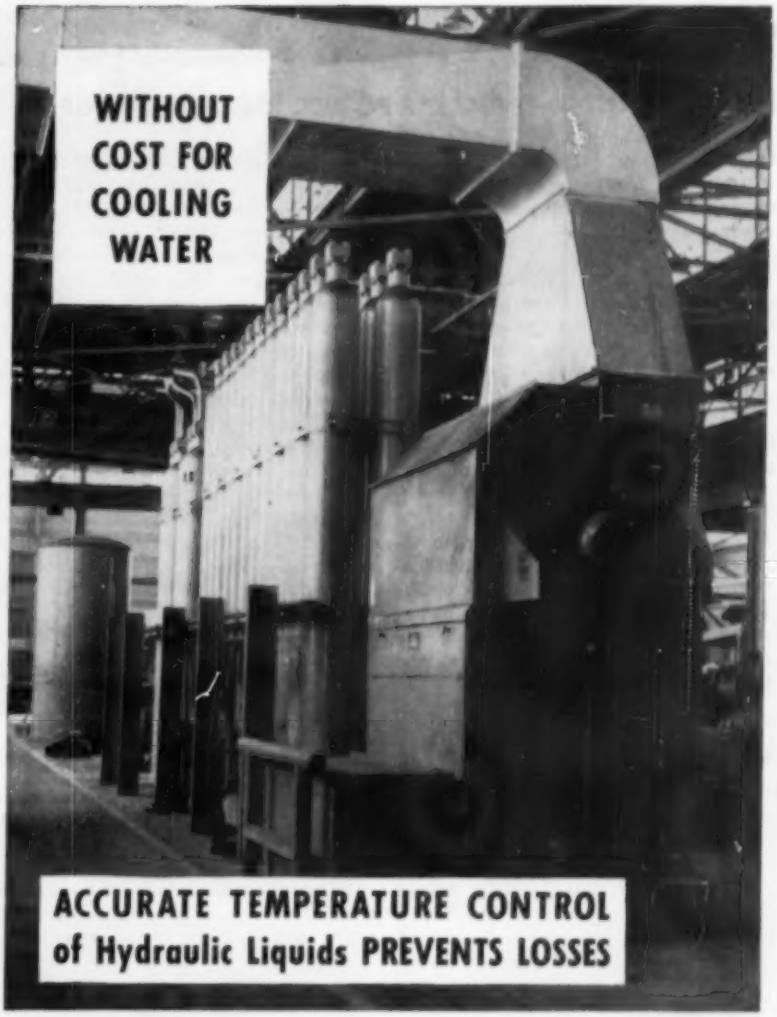
The Soviet nuclear explosion in March may have used thorium-232 as the principal element. This was the crux of the report of S. Koyama, Niigata Univ., to the Japan Meteorological Society. Koyama based his conclusion on tests of radioactive rain which fell in Japan after the March Soviet blast. These tests gave significantly different results from those made after earlier Soviet thermonuclear explosions. Neptunium-239 and uranium-237, both abundant in rainwater after former blasts, were absent this time. On the other hand, strontium content just about equaled barium content this time, and rubidium-86 was found for the first time—the rubidium was in quantities of about 2 per cent. □

The most representative display of chemical technology and production in the British chemical industry in history occurred at the British Industries Fair which closed May 4 at the Olympia in London. In Britain, the chemical industry as a whole is expanding at a rate twice that of other British industries, now ranks fourth of the country's export industries. One-third of its total output went overseas last year, including $21,280,000 worth to the United States.

British chemical industry is expanding rapidly, as the Fair demonstrated, and one facet, the petrochemical industry, already has an output that exceeds any other country in the world except the United States. □



First "swimming pool" research reactor ordered from an American manufacturer by a Latin American nation is the new 5000-kw. reactor to be built and installed by Babcock & Wilcox for Brazil's Comissao de Energia Atomica. Fuel will be furnished by AEC under one of the 25 bilateral agreements entered into by the U. S. Fuel elements will be only 20% enriched in U-235, lower than used in research reactors in the U. S.



● This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

Air is free and cheaper to move than water. You can save much expense in pumping, piping and power, and quickly recover the equipment cost from the water saving.

Similar Niagara machines cool water, oils, solutions, lubricants and coolants for many mechanical, electrical and chemical processes. You can cool quench baths, welding machines, plastic molds, furnaces, controlled atmospheres, gases, compressed air either for power or instruments or processes. In a closed system, your coolant is never contaminated. The system is simple and easy to keep up; the equipment has a long, useful life. Select from a wide range of sizes up to 30,000,000 BTU.

Write for Bulletin 120 to obtain a complete description.

NIAGARA BLOWER COMPANY

Dept. EP, 405 Lexington Ave. New York 17, N. Y.

Niagara District Engineers in Principal Cities of United States and Canada

INDUSTRY AND THE NUCLEAR POWER REACTOR PROGRAM

Industry now joins AEC in the vital work towards the complete commercial development of nuclear power.

The power reactor development program of AEC consists of three main parts: the development of basic technology, the testing of concepts by integrated reactor experiments, and the power reactor program with the cooperation of industry.

The reactor experiments of AEC have been in operation for some time now, are widely known. Under the provisions of the Five-Year Program for Power Reactor Development, announced in March, 1954, five types of large, advanced reactors are to be operated and studied by AEC. One of these, the Pressurized Water Reactor at Shippingport, Pa., brought industry into the picture as builder (Westinghouse) and operator (Duquesne Light Co.).

But to accelerate the development of commercial power reactors, AEC announced the Power Demonstration Reactor Program in January 1955. Purpose: to encourage the construction of prototype power reactors by industry or publicly-owned electric utilities. AEC is prepared to underwrite at least part of the cost of research and development associated with any such projects on a "closed-end" basis. The table shows the reactors already proposed.

In September, 1955, AEC made a second proposal to industry, inviting proposals for small power demonstration reactor projects, limiting the power ranges to between 5000 and 40,000 kilowatts. Seven proposals have now been received: Chugach Electric at Anchorage, Alaska, and Nuclear Development Corp., White Plains, N. Y.—a sodium-cooled, heavy water moderated reactor of 10,000 kw. City of Holyoke Gas & Electric Dept., Holyoke, Mass.—a gas-cooled reactor with closed-cycle gas turbine, 15,000 kw., design agent is Ford Instrument Co. City of Orlando, Fla.—liquid metal fuel reactor, 25,000 to 40,000 kw. City of Piqua, O.—organic moderated reactor, 12,500 kw., design agent is Atomics International, North American Aviation. Rural Cooperative Power Assoc., Elk River, Minn.—boiling water reactor, 22,000 kw., design agent is American Machine & Foundry. Univ. of Florida, Gainesville—pressurized light water reactor, 2,000 kw. Wolverine Electric Cooperative, Hersey, Mich.—aqueous homogeneous reactor, 10,000 kw., design agents are Foster Wheeler and Worthington.

CENTRALIZED INSTRUMENTATION FOR NUCLEAR REACTOR

New Penn State reactor has latest in operating and safety controls.

Engineered by Leeds & Northrup, measuring and controlling systems guide the operation of the Penn State research reactor safely through the critical raising of power levels, automatically hold

Proposed Prototype Power Reactor Plants

Company	Westinghouse* and Duquesne Light Co.	Yankee Atomic Electric Co.	Consolidated Edison Co.	Commonwealth Edison and others	Consumers Public Power District	Power Reactor Dev. Co. (Det. Ed. et al)	Westinghouse and Pennsylvania Power and Light
Location	Shippingport, Pennsylvania	Western Massachusetts	Indian Point, New York	Near Chicago	Nebraska	Detroit Edison Service Area	PP&L Service Area
Type of Reactor	Pressurized Water (PWR)	Pressurized Water	Pressurized Water	Boiling Water	Sodium-Graphite	Fast Breeder	Homogeneous
Thermal Power	236,000 Kw	480,000 Kw	500,000 Kw	682,000 Kw	250,000 Kw	300,000 Kw	....
Gross Generating Capacity	100,000 Kw	134,000 Kw	250,000 Kw**	180,000 Kw	75,000 Kw	100,000 Kw	150,000 Kw
Amount of Fuel	12 T natural U and 52 Kg	28,800 Kg	275 Kg U and 8,100 Kg Th	68,000 Kg	24,600 Kg	2,100 Kg	....
Enrichment Per cent U-235	about 90%	2.7%	About 90% for U	1.1%	1.8%	20%	....
Moderator	H_2O	H_2O	H_2O	H_2O	Graphite	None	....
Coolant	H_2O	H_2O	H_2O	H_2O	Sodium	Sodium	Fuel Solution
Reactor Temp.***	540° F.	535° F.	500° F.	480° F.	925° F.	800° F.	....
Reactor Pressure	2,000 Psig	2,000 Psig	1,500 Psig	600 Psig	300 Psig	100-200 Psig	....
Steam Conditions	585 Psig Saturated	600 Psia Saturated	420 Psia Saturated	600 Psia 480° F.	800 Psig 825° F.	600 Psia 730° F.	600 Psia ....
Estimated Cost of Reactor****	$27,700,000	$17,400,000	....	$34,200,000	$13,500,000	$36,000,000	....
Est. Cost of Turbo-Gen. Plant	$10,000,000	$16,000,000	....	$10,800,000	$10,800,000	$ 9,000,000	....
Total Estimated Plant Cost	$37,700,000	$33,400,000	$55,000,000	$45,000,000	$24,300,000	$45,000,000	....
Cost Per KW	$370	$246	$230	$250	$320	$540	....
Estimated Completion Date	1957	1959-60	1960	1960	1958-9	1959-60	1962

* This reactor is being built by the AEC; Westinghouse and Duquesne are prime contractors to the AEC.
** Includes 110,000 Kw of conventional superheating capacity.
*** Average temperature of coolant in reactor.
**** Not including research and development, fabrication of fuel elements for first charge, or nuclear materials. Fuel element fabrication and nuclear materials are included in fuel costs.

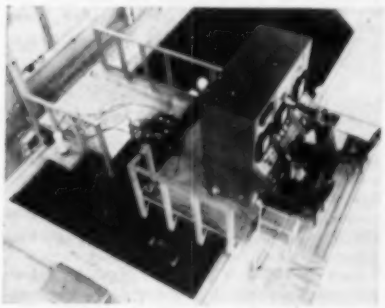
the power within plus or minus one per cent of the desired operating level.

The $300,000 reactor is primarily a source of neutron beams and will greatly simplify instruction in nuclear science. Special projects for Pennsylvania industry are also planned.

Instrumentation

Few processes present more difficult control problems than a nuclear reactor. Power levels change rapidly and widely, the process possesses no "capacity" to stabilize control action, and the system must have fast scram for certain unsafe conditions without unnecessarily interfering with operation at other times.

At Penn State, separate systems, called channels, guide reactor operation for: (a) initial start-up, (b) intermediate power build-up, and (c) automatic control at the operating power level. Additional channels provide for slow, intermediate and fast scram.



The control cubicle with channel recorders is located on the bridge across the reactor pool. Mounted directly over the reactor in the center of the bridge is the electric drive unit which positions the control rods.

At start-up, a log count rate monitors reactor operation. Individual neutron count in a fission measuring chamber is measured electronically, the logarithm of its value plotted on a strip-chart recorder, and the operator uses the chart as a guide for manually raising the reactor control rods at the proper rate.

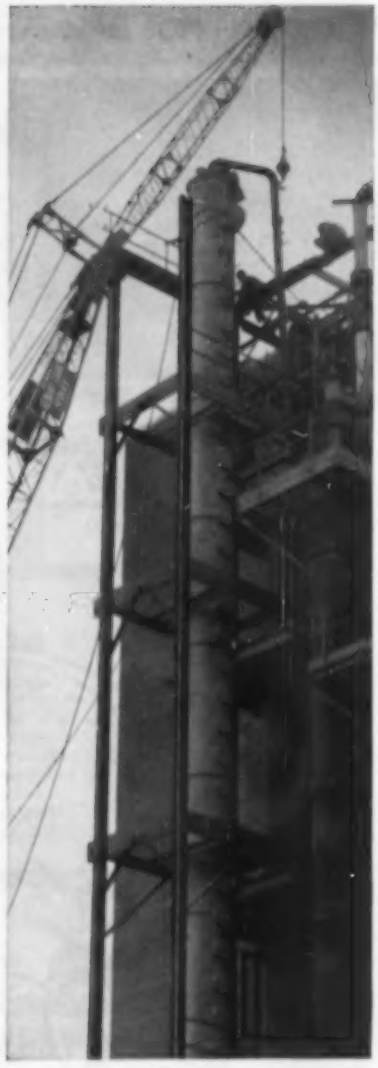
As nuclear energy builds up, the operator transfers his attention to the log N recorder, which plots the logarithm of the reactor flux as a measure of power level.

The third channel, the linear servo, automatically controls the reactor at operating power level when the chain reaction is self-sustaining.

During power build-up, if the rate of power increase exceeds the prescribed limit, safety circuits take over. These are built into the log N channel to produce fast scram by inserting safety rods into the active lattice of the reactor core, bringing the controlled chain reaction to a complete and rapid halt.

Line-up was checked with transit to hold close tolerances during welding. Tower passed rigid inspections, was Code stamped.

Motor freight saved time and cost.



Field erection went smoothly.

80-tray tower...by Downingtown

Complete mechanical design and fabrication by Downingtown Iron Works. 80 trays welded in shell. Tray flatness held to unusually close tolerance. Ten-inch handhole at each tray. Customer more than satisfied with performance of tower. Send now for Bulletin PF. See what we've done for others...learn what we can do for you on towers, pressure vessels, process equipment.

Diameter: 36″

Total Height: 92′ 6″

Shell Thickness: ⅝″, ½″ and ⅜″

Material: Carbon steel

80 trays, 45 bubble caps per tray

Downingtown Iron Works, Inc.

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

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DOWNINGTOWN IRON WORKS Hackney

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

FUTURE MEETINGS and Symposia of the Institute

Air view of Pittsburgh's "Golden Triangle."

MEETINGS **SYMPOSIA**

■ **PITTSBURGH, PA.**

Sept. 9-12, 1956. Wm. Penn Hotel.

See page 61 of this issue for further news on the coming Pittsburgh meeting.

TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

Mixing

CHAIRMAN: J. H. Rushton, Dept. of Chem. Eng., Purdue U., Lafayette, Ind.

Distillation Computation Methods

CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

Scientific Aids to Management (Chemical Engineering Operations Research)

CHAIRMAN: George D. Creelman, Creelman Associates, 10524 Wilbur Ave., Cleveland 6, Ohio.

Case studies showing a wide variety of methods and techniques in applications of operations research in chemical engineering.

Explosions in Chemical Engineering

CHAIRMAN: G. H. Damon, 366 Ashland Ave., Pittsburgh 28, Pa.

Symposium on gas and dust explosions.

Unit Operations in Nuclear Engineering

CHAIRMAN: George Sege, General Electric Co., 2155 So. First St., San Jose, Calif.

How a basic training in chemical engineering fits into the work involved in the field of nuclear engineering, discussing results of unit operations researches done in conjunction with atomic energy projects.

General Papers

■ **ANNUAL—BOSTON, MASS.**

Dec. 9-12. 1956 Hotel Statler

TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Filtration

CHAIRMAN: F. M. Tiller, U. of Houston, Cullen Boulevard, Houston 4, Tex.

The flow of liquids through compressible media with experimental and theoretical papers.

Low Temperature Techniques

CHAIRMAN: Clyde McKinley, Air Products Inc., Allentown, Pa.

Papers dealing with gas prepurification for low-temperature processing and the low temperature aspects of heat exchange, refrigeration, distillation and liquid-vapor equilibria, and the properties of materials.

The Sales Engineer in Chemical Engineering

CHAIRMEN: W. E. Hesler, Rodney Hunt Machine Co., 420 Lexington Ave., N. Y. C. 17, E. D. Kane, Cuno Eng. Corp., S. Vine St., Meriden, Conn.

Three Panels: "Introducing Mr. Chemical Sales Engineer," "Training the Chemical Sales Engineer," "Performance Yardstick of the Chemical Sales Engineer."

Afternoon at the Ichthyologists

General Session: "Obsolescence" of Chemical Engineers. Sunday P.M.: Round table discussion.

Deadline—August 9, 1956

■ **WHITE SULPHUR SPRINGS, VA.**

March 3-6, 1957.

■ **PHILADELPHIA, PA.**

March 11 through 15, 1957 (probable)

Nuclear Engineering Division Congress and Atomic Exposition, Philadelphia. "The Fuel Cycle."

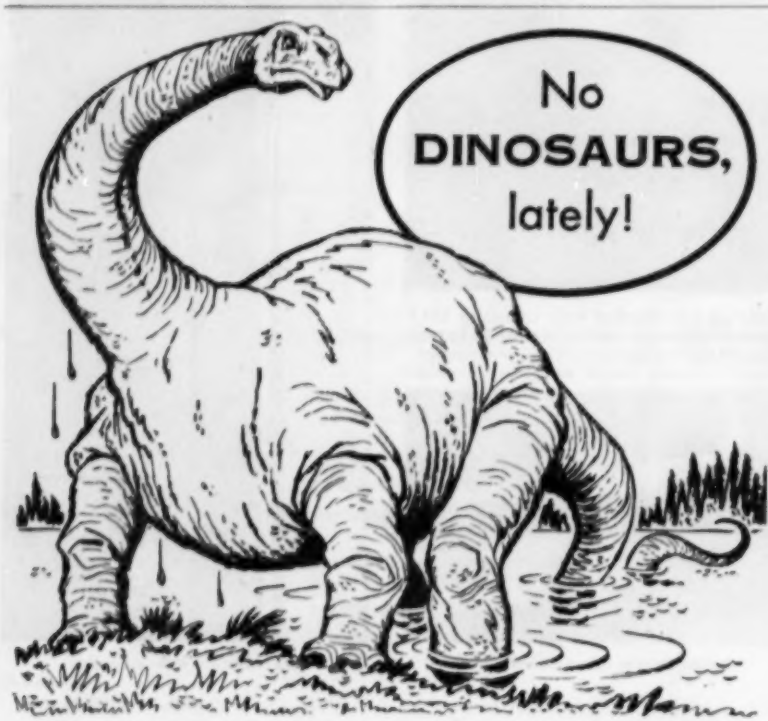
Expected to be confined to subjects directly applicable to the overall nuclear fuel cycle. Fuel cycles for power plants and possible plants utilizing high temperature heat are envisioned.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited.

Laboratory and Pilot Plant Techniques

CHAIRMAN: To be assigned.



The extensive magnesium silicate deposits laid down about the time dinosaurs roamed Florida's marshy peninsula became the source of today's most wisely used adsorbent.

Because it contains numerous small fibrous tentacles, Florida Fullers Earth, in its commercial form known as Florex, is particularly valuable in the adsorptive refining, decolorization, clarification and neutralization of mineral, vegetable, and animal oils, fats and waxes. Florex is unequalled in high quality or low cost for processes involving the use of highly active clay for sweetening light distillates, dehydration, desulfurization, and polymerization.

Standard meshes from 2/4 to 200/up and our experienced adsorption specialists are available to help you solve complex laboratory or production problems.

FLORIDIN COMPANY Adsorbents Desiccants Diluents

Dept. Z Box 989 Tallahassee, Fla.

Centrifugation

CHAIRMAN: James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kan.
The theory and quantitative aspects of centrifugation.

Fluidization of Solids

CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.

Drying

CHAIRMAN: Ralph E. Peck, Chem. Eng. Dept., Illinois Institute, 33rd Federal, Chicago 16, Ill.

Direct Operating Labor Costs

CHAIRMAN: John Happel, Chem. Eng. Dept., New York U., University Heights 53, N. Y.

Size Reduction

CHAIRMAN: Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

Filtration & Centrifugation

CHAIRMAN: Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.

Corrosion Resistant Alloy Materials of Construction

CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

Dry Classification of Solids

CHAIRMAN: D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.

Chemical Plant or Petroleum Process Plant Cost Estimates

CHAIRMAN: C. W. Nofsinger, the C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

New Chemical Engineering Construction Techniques

CHAIRMAN: S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.

Mineral Process Engineering and Mineral Economics

CHAIRMAN: L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.

LOCAL SECTION MEETINGS

■ **NEW YORK**

June 19, 1956, luncheon meeting, Brass Rail, 49th St. & 7th Ave. "Code of Engineering Ethics" or "Garden Chemicals."

September 28, 1956, dinner meeting, Brass Rail, 43rd St. & 5th Ave. "Sonics and Ch. Eng."

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to former if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

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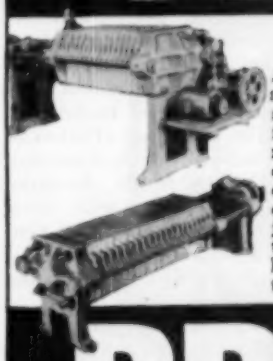

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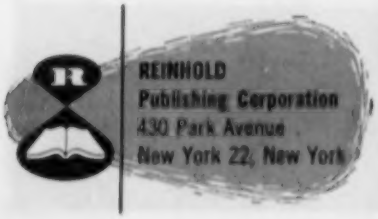

INSTITUTIONAL NEWS

NEW INTERNATIONAL REGISTER AIDS CONTACT WITH EXPERIENCED PERSONNEL

A Central Index of Educational Exchangees has been established which gives complete statistics on Americans studying abroad, and foreigners studying here, since 1919.

Among many highly important uses for the new register of internationally trained personnel, perhaps the most important to American and foreign industry is its great potential as a source for the location and utlization of trained specialists.

Established by the Institute of International Education, with financial assistance from the Ford Foundation, the new Central Index is a roster of Americans who have gone abroad, and foreigners who have come here, for educational purposes during the last 36 years. It contains 212,696 names, is most complete for the more recent exchangees.

It is, basically, a reservoir of information in internationally trained persons, of great value to private American firms and foreign firms with international interests, to international non-industrial organizations, to professional groups and educational institutions, and to Governmental agencies.

Since the start of its preparation in 1953, the Index has been used by many business firms with personnel recruitment problems who have requested names and addresses of foreign experts with U. S. training in specialized fields.

Since the Index's value as a source of personnel information requires that it be kept current, the Institute plans to maintain it as a cumulative roster, which in turn entails considerable expense and necessitates a charge for its services at this time.

The combination of a two million volt Van de Graaff particle accelerator and New York University's sub-critical "pickle barrel" reactor, makes it possible for the University to use its equipment for research as well as educational purposes. The University has already begun reactor experiments with the new tool.

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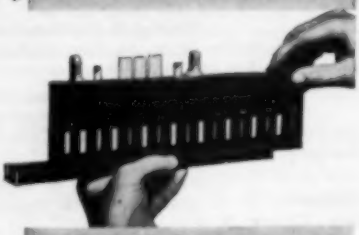

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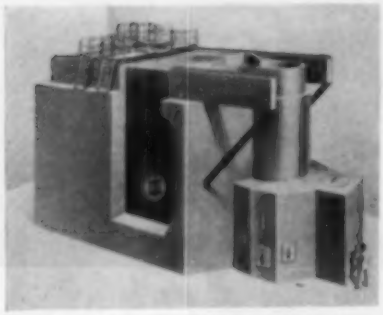

Experiments aimed specifically at perfecting ways of using nuclear radiation in petroleum refining and in the production of petrochemicals, will be conducted at Battelle Memorial Institute by the Institute's scientists, will be paid for by Esso Research and Engineering at the rate of $250,000 per year over three years. Heart of what Battelle describes as the nation's most complete non-Government atomic research center is this "swimming pool" reactor.

An experimental study program on the graduate level for gifted undergraduate engineering and science students will be conducted for the second successive year this summer at Rensselaer Polytech. The six-week program, July 23 to August 31, will be two concurrent courses this summer, Modern Physical Chemistry of Metals and Modern Metal Physics, for students majoring in chemical engineering, metallurgical engineering, chemistry and physics. Last summer's work indicated that some students could be successfully advanced to graduate level in this way without benefit of the senior year. □

To help meet the critical shortage of engineers trained in nuclear engineering, and to assist management men who need the basic concepts of nuclear science, the Univ. of California will conduct two important courses this summer at Berkeley. July 2 to August 31, will be the Nuclear Engineering short course for those with technical responsibility. Designed to closely parallel the one-year program at Oak Ridge School of Reactor Technology, the course will have 260 intensive hours of instruction, will cost $600 including laboratory fees. July 9 to July 14 will be the one week course designed to present a condensed version of various aspects of reactor technology to those who must plan and administer activities relating to nuclear engineering. This fee is $100. □

A library devoted exclusively to solar energy is now in operation at the headquarters of the Association for Applied Solar Energy, Phoenix, Ariz. The library contains more than 2500 references in the form of technical papers, articles and patents dealing with solar energy research and development, and the few books which exist on the subject. □

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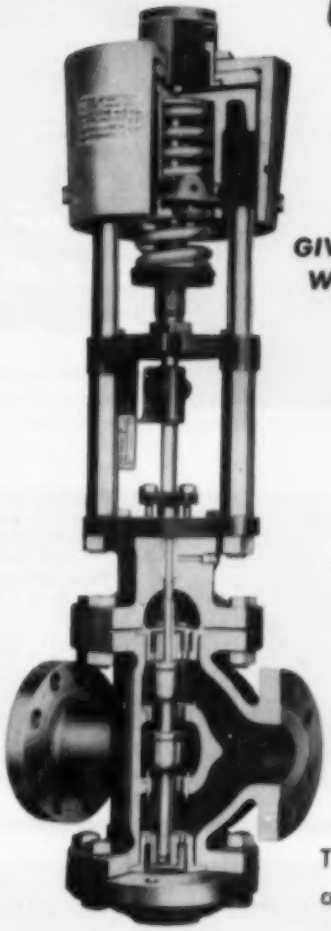

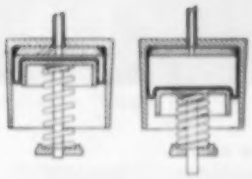

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at the NEW ORLEANS MEETING

OUR BUSY PRESIDENT—

AT HOUSTON AIRPORT, l. to r., W. M. Hathaway, So. Texas Section; G. W. Brakefield, representing Houston's mayor Holcombe; pres. Whitman; W. L. Bolles & D. G. Schroeter, chairman & vice-chairman, So. Texas Section.

FOREIGN DEVELOPMENTS PANEL SESSION

WDSU-TV "Sunday Supplement" —pres. Whitman being interviewed by Bill Monroe on shortage of high school science teachers.

STANDING ROOM ONLY

AWARDING secretary's pin to H. C. Parmelee, second man to hold that office in A.I.Ch.E. (1927-29).

SEEN AT THE COCKTAIL PARTY

W. E. McWhirter, Jr., vice-chairman Plant Trips; Mrs. McW.; R. V. Bailey, Technical Program; Mrs. B.; Mrs. Taylor; R. M. Taylor, chairman Hotel & Meeting Rooms.

ARRANGEMENTS CO-CHAIRMEN & WIVES . . . (above) Mr. & Mrs. Walter Godchaux, New Orleans; (below) Mr. & Mrs. L. H. Stephens, Baton Rouge.

HIGHLIGHT SOCIAL EVENT of New Orleans Meeting was Mardi Gras Pageant staged by professional entertainers at Tuesday banquet. Characterization at lower left is one of masks used in each full scale Mardi Gras parade. Other pictures show Dixieland jazz band in action.

L. J. Governale, vice-chairman Entertainment, with Mrs. Governale, co-chairman Ladies.

H. J. Molaison, chairman Printing, and Miss Muriel Rooney.

Mr. & Mrs. C. S. Williamson, Jr. Mr. Williamson was a special guest of the New Orleans Meeting; was formerly head of Chem. E. at Tulane.

Mrs. O'Connell and Mr. H. E. O'Connell, chairman Technical Program.

Mr. and Mrs. C. H. Fisher.

NEXT MONTH—

- **ESSO PLANT TRIP**
- **SOUTHERN REGIONAL LAB PICTURES**

What Happened at New Orleans

With attendance reaching 1,100, New Orleans was an important meeting in many respects. Of probable long range consequence was the day-long meeting devoted to discussion of matters of Local Section interest, reported on herewith . . .

A day-long conference planned by the new Local Sections Activities Committee was held in connection with the New Orleans National Meeting of the Institute. The purpose of the meeting was to inform Local Section Officers and Officers of the Institute as to affairs of mutual interest. The meeting was well attended; 48 Local Section Officers, almost all members of Council, and Chairmen of five Institute committees were present.

The first part of the morning program covered the activities of the Membership and Professional Development Committees. The chairman of the Membership Committee, John McKetta, spoke about the membership program and made a number of suggestions as to how to talk to young men who are starting their professional careers, about the advantages of Institute membership. McKetta urged that the Section Officers encourage and work with Membership Committee representatives in each Local Section, to help achieve the new member goals.

There was some discussion regarding the variable practice among Local Sections in requiring membership in the Institute as a prerequisite to membership in the Local Sections. There appear to be advantages and disadvantages in such requirements. Most sections do not require Institute membership, although several of the large sections do make this requirement. It should be noted that it is the policy of the Institute to allow this decision to be made by each Local Section.

Professional Standards Committee

Ray P. Dinsmore spoke about the work of the Dinsmore Committee in preparing the Statement on Professional Standards. (See C.E.P. 51, 50, Nov. 1955). This statement has received wide circulation and excellent reception not only by chemical engineers but others in the engineering profession. The Dinsmore Committee is a special committee of Council set up to guide Institute policy on Professional Standards. Although the Statement is now completed, the Committee is continuing to function so that the principles of the Statement may be carried to members of the profession and to industrial employers of chemical engineers. To this end, the Committee has organized luncheon meetings for business executives, to tell them of the principles of the Statement and the reasons for Institute interest in promoting Professional Standards. The success of the Committee's efforts in taking the story of Professional Standards to employers appears to be well assured. Industry representatives are very receptive to the aims, and many have expressed their determination to do their part to establish high principles of professional conduct in their dealings with their engineering employees.

The Professional Development Committee (represented by W. E. Keppler) is formulating plans for implementing a number of ideas brought out in the Professional Standards Statement. Mr. Keppler told of his Committee's recommendations of policies to Council. Council has already voted to implement some of the suggestions, and these actions will be reported to the membership through the Secretary's page (News and Notes) in C.E.P.

The purposes of Engineers Joint Council (E.J.C.) and Engineers' Council for Professional Development (E.C.P.D.), and Institute relations and participation with these groups were other subjects of discussion at the morning meeting.

W. E. Lobo explained the objectives and operations of E.J.C., a body made up of representatives of a number of engineering societies who consider matters of general interest to the engineering profession. A.I.Ch.E. participates in it (based on our total membership) with two representatives who report to Council. They follow legislation which effects engineers, participate in manpower studies, and provide information to government groups on many matters of professional interest to engineers. The President of E.J.C. for the current year is A.I.Ch.E. past president T. H. Chilton.

G. G. Brown, one of the A.I.Ch.E. representatives on E.C.P.D., outlined its various activities. It is supported by eight engineering societies representing civil, mechanical, electrical, chemical, and mining and metallurgical engineers —also, the Engineering Institute of Canada, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners. Representatives of each of the societies make up the Executive Committee of E.C.P.D. The Executive Secretary is S. L. Tyler, retired Executive Secretary of A.I.Ch.E. One of the major activities of E.C.P.D. is its Education and Accrediting Committee covering all branches of engineering. There are three A.I.Ch.E. members on this committee, all of whom are tied in closely with our own Education and Accrediting Committee work. Accreditation of curricula in chemical engineering must first be approved by our own committee and Council before being submitted to E.C.P.D. Other activities of E.C.P.D. have to do with guidance, student development, ethics, information on the practice of engineering, and similar subjects. C.E.P. Editor John Mellecker reported on the work of the Information Committee. Brochures are developed from time to time explaining the work and interests of engineers for use at the high school level in informing young men about careers in engineering.

Engineering Center

B. F. Dodge reported the present status of plans for a new Engineering Center. The consulting firm of McKinsey and Co. have been engaged to study the problem of best location for an Engineering Center and to report their findings and recommendations to a committee of five past presidents of the engineering societies. Dr. Dodge is chairman of this committee. He expects the final report from the consultants to be available during June, and that definite action can then be taken by the Councils of each of the societies.

The need for rapid communications between Council and Institute Committees and officers with local sections was discussed at length by Mr. Van Antwerpen and Mr. Vause. Present techniques were explained and Mr. Van Antwerpen told of the need for a full time person on the New York staff to develop closer liaison with the Local Sections. Funds have been budgeted by Council for this staff member, but the position has not yet been filled. E. H. Vause of the Chicago Section had made a study, by way of a questionnaire, of suggestions for improving communications between the national organization and the Local Sections. A number of ideas were developed during presentation of his findings. As a result, the Sections Activities Committee will prepare a manual for use by Local Section Officers informing them of the various Institute committee activities, policies of the Institute, and other items of interest.

Dr. Whitman gave a short talk to the group stressing the professional attitude of engineers and brought up the fact that professional people the world over have much in common through their profession. He closed his remarks with a very thought-provoking illustration in which he told of one of his deputies on the Atoms for Peace Committee (Geneva Conference) whose father was a noted Russian biologist. When the Russian government decreed that the Lyzenko theory was to be the official biological belief of the Russian people, the father was sent to Siberia; he held to his professional beliefs.

Dues Collection

E. F. Von Wettberg, Jr., of the Philadelphia-Wilmington Section, arranged a panel discussion on the collection of Local Section dues. W. L. Bolles of South Texas, G. E. Dean of Tidewater, Virginia, C. W. Peters of New Orleans, and L. P. Scoville of Council participated in the panel discussion. Von Wettberg had questioned all sections of the society on the matter of dues and their collection. He found that dues varied from one to five dollars per year with most sections at the two dollar level; most sections preferred to collect their own dues. The consensus of the questionnaire results and of the speakers was that most people favored collection of dues by the Local Section rather than from the treasury of the Institute.

Operations Problems

D. D. MacLaren of the New Jersey Section organized a panel discussion on operations problems of Local Sections. H. F. Nolting, Chicago Section, N. K. Heister, Northern California Section, and B. B. Kuist of the Southern California Section took part with Mr. Mac Laren and discussed matters of career guidance, professional legislation, statistics on effects of location and type of meeting programs on attendance, and on job descriptions of Local Section Officers. Mrs. W. B. Franklin told about the Ladies Auxiliary of the South Texas Section. The wives of the Local Section members have held regular luncheons followed by an inspection trip through some industrial plant in the area. The South Texas Section reports that this has resulted in an increased awareness by many of the chemical engineers of the area of the activities of A.I.Ch.E. No doubt other sections would find a Ladies Auxiliary to be of considerable interest to chemical engineers' wives.

Prof. Rushton wishes to thank all those who took part in the meeting and contributed to its success. A similar half-day meeting is tentatively planned for the annual meeting in Boston in December.

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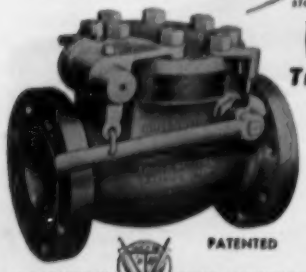

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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before July 15, 1956, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Adams, James F., *Webster Groves, Mo.*
Albright, Lyle F., *Lafayette, Ind.*
Andrews, Herbert W., *Westfield, N. J.*
Benjamin, William J., *Walnut Creek, Calif.*
Blackmun, Lynn A., *Westend, Calif.*
Braithwaite, Charles H., Jr., *So. Charleston, W. Va.*
Bunker, Frank C., *Warwick, Va.*
Byrne, Joseph, *Concord, Calif.*
Degnan, Thomas F., *Wilmington, Del.*
Doud, Edward, *Richland, Wash.*
Erskine, A. M., *Berkeley, Calif.*
Evans, John D., *Naugatuck, Conn.*
Fritz, E. J., *Deepwater, N. J.*
Gruen, Ernest J., *Edgewood, Md.*
Johnson, Clarence A., *Princeton, N. J.*
Kelso, George, *Upper Darby, Pa.*
Marsel, Charles J., *New York, N. Y.*
Mason, Thomas R., *Lake Charles, La.*
Miessner, Horst H., *Leverkusen, Bayerwerk, West Germany*
Mosesman, Max A., *Baytown, Tex.*
Nelson, Richard Lee, Jr., *Cincinnati, Ohio*
Neubert, Ronald H., *Pittsburgh, Pa.*

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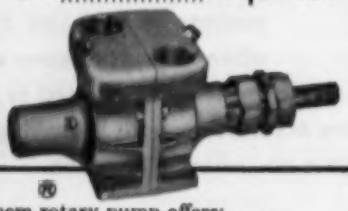

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Powell, Gerald, Lake Jackson, Tex.
Raff, Albert S., New York, N. Y.
Rambosek, George M., St. Paul, Minn.
Riess, J. G. Kurt, Leverkusen, Bayerwerk, West Germany
Rodrigues, James L., Springfield, Mass.
Sauerborn, Alfred J., Aiken, S. C.
Shambaugh, Edward J., Philadelphia, Pa.
Shprintz, Lawrence, Philadelphia, Pa.
Wilkenfeld, Jerome, Niagara Falls, N. Y.

Associate

Adler, Leonard L., East Chicago, Ind.
Alterman, David S., Buffalo, N. Y.
Armstrong, Paul L., Jr., Grand Island, N. Y.
Ayres, Alvah W., East Alton, Ill.
Benes, Richard, Argo, Ill.
Ben-Ezra, Aaron J., Johnson City, N. Y.
Bolton, Virginius D., Niagara Falls, N. Y.
Boyer, Howard A., Morristown, N. J.
Braulick, W. J., Baton Rouge, La.
Carr, William D., Monroe, La.
Chew, V. Collins, Kingsport, Tenn.
Chin, Howard L., New York, N. Y.
Christensen, Donald A., Arlington, Va.
Claflin, Donald N., Houston, Tex.
Cooke, Norman E., Montreal, Que., Can.
Czerny, Bohdan R., New York, N. Y.
Day, John W., New Castle, Del.
Donner, Thomas, Forest Hills, N. Y.
Drummond, William H., Texas City, Tex.
Evens, Gene E., Calvert City, Ky.
Forbath, T. Peter, New York, N. Y.
Gause, Luther P., Jr., Memphis, Tenn.
Goundry, Paul C., Houston, Tex.
Grant, Edward R., Los Angeles, Calif.
Grossman, Mervyn, New York, N. Y.
Gutstein, Martin U., New York, N. Y.
Hajjar, Abraham L., Stamford, Conn.
Hoffman, Charles F., Jr., Verona, Pa.
Hoover, Charles G., III, Aliquippa, Pa.
Jacobson, Conrad B., Houston, Tex.
Jacobson, Orin B., Minneapolis, Minn.
Johnson, Benjamin M., Richland, Wash.
Johnson, Dennis E., Cambridge, Mass.
Kaplan, Howard R., Stamford, Conn.
Keepers, J. A., Texas City, Tex.
Kephart, Horace L., Swarthmore, Pa.
Killmeyer, Donald J., Pittsburgh, Pa.
Knox, Roger E., Wilmington, Del.
Lachman, Robert I., Pittsburgh, Pa.
Latinen, George A., Wilbraham, Mass.
Lewis, Clarke H., Jr., Berkeley, Calif.
Luther, M. W., Glen Mills, Pa.
McCauley, James K., Jr., Pittsburgh, Pa.
Myers, Cecil E., Fort Benning, Ga.
Nagel, Donald A., Chicago, Ill.
Nardini, Robert F., Grand Island, N. Y.
Nelson, David B., Monsanto, Ill.
Nelson, Leigh E., Concord, Calif.
Pace, John M., Lake Jackson, Tex.
Phillips, Yorke P., Springfield, Mass.
Piplani, Om Prakash, Chicago, Ill.
Robinson, Harold L., So. Charleston, W. Va.
Schiffhauer, F. A., Claymont, Del.
Scott, Robert J., New Martinsville, W. Va.
Sigman, Theodore, Brooklyn, N. Y.
Sorgenti, Harold A., Columbus, Ohio
Spitz, Peter H., New York, N. Y.
Sutaria, G. C., Syracuse, N. Y.
Switzer, Steven M., Queens, N. Y.
Tichler, Paul Robert, Brooklyn, N. Y.
Towne, Myles K., Jr., Wright-Patterson A.F.B., Ohio
Waldman, Louis A., Pittsburgh, Pa.
Wehner, J. Francis, Washington, D. C.
Weinreb, Harold G., New Haven, Conn.
Welch, John F., Painesville, Ohio
Williams, Charles D., Baltimore, Md.
Williamson, Earl W., Niagara Falls, N. Y.
Wolf, Edgar B., Bradley Beach, N. J.

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For several years the Professional Development Committee of the Institute has been engaged in an active campaign to encourage local sections to sponsor professional study courses for members. Designed to promote the development of professional attitudes among the members, and to provide a practical means for developing technical and over-all competence for advancement to positions of increased responsibility, the study course method has proven highly useful, highly stimulating, and remarkably practical when operated correctly and efficiently as described in this article which reports in detail on the experience of the Charleston (W. Va.) Section since 1951.

ADVANCED STUDY COURSES ATTRACT CHEMICAL ENGINEERS

W. R. Manning

Carbide and Carbon Chemicals Company
Member, Professional Development Committee, A.I.Ch.E.

Study courses on such subjects as Heat Transfer, Thermodynamics, Cost Estimation, Chemical Economics and Finance, and Technical Writing have brought 1190 chemical engineers, 44 expert lecturers, and a substantial cash balance in the Study Course fund to the now five-year-old program of the Charleston (W.Va.) Section.

The highly successful professional study course program for chemical engineers, sponsored by the Charleston Section, began in the fall of 1951 with a course in Advanced Distillation. Since then the program has continued and expanded until it is today a model of efficient professional development activity.

Organization and Operation of Courses

All arrangements for the courses at Charleston are handled by a Study Course Committee of six to eight members of the section. Effort is made to have each of the several chemical companies with plants near by represented on the committee. The chairman of the Study Course Committee is a member of the Executive Committee of the Section. Each year, early in June, the Study Course Committee is appointed and begins to plan the courses to be offered in the fall and spring. Selection of the courses is based upon the results of a questionnaire which has been circulated in March or April by the previous Study Course Committee to all members of the local section. After the courses are selected, the committee outlines a tentative curriculum for each course and prepares a list of possible lecturers. One committee member is assigned the responsibility for obtaining a speaker for one or more lectures, and for making all arrangements for that speaker's accommodations, transportation, and entertainment during his visit. Other duties of the committee, such as arranging for lecture room, obtaining special equipment which may be required, and printing notices of the class sessions, are divided among the committee members.

Each course consists of six to eight lectures presented at two-week intervals. The fall course begins about the middle of September and is completed by the middle of December. The spring course begins about the middle of January and is completed by the end of April. All class sessions are held in the evening, and each session lasts from two to three hours. Each session consists of a lecture followed by a discussion period for answering questions and discussing problems. The lecturer is asked to provide a set of notes and appropriate problems for reproduction and distribution to the class members before the lecture, eliminating the need for extensive note-taking during the lecture, and allowing full concentration on the presentation. All classes are held at Morris Harvey College, Charleston, where excellent class-room facilities have been made available through the courtesy of the college administration.

Financing

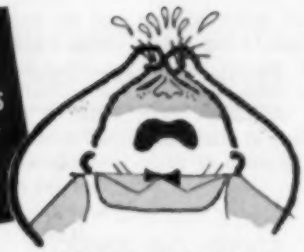
The Executive Committee of the Section wanted the study courses to be entirely self-supporting and not dependent on either the local section or on local industry for financial assistance. To this end, a fee of six to eight dollars per course (depending on the number of lectures) was established for members of the local section (nonmembers may also enroll in the courses at an additional cost of $1.50 per person). The maximum number of people who may be enrolled in a course is fixed by the capacity of the available lecture room at about 150. For several of the courses the number of applicants has exceeded 150, and some had to be refused. Because of the enthusiastic support of the courses by the members of the local section and by nonmembers, the income from the courses has always been more than sufficient to pay all expenses for the courses, including the travel expenses of the speakers plus a small honorarium. At present a substantial cash balance exists in the Study Course Fund as a cushion against contingencies.

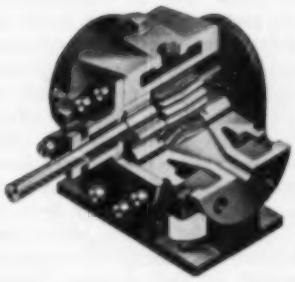
Range of Subjects

The Study Course Committees have endeavored to ascertain what courses are most desired by the members and to present those courses. A wide range of subjects, both in chemical engineering and in other fields, has been covered

(*Continued on page* 108)

DON'T GIVE UP
when viscous liquids cause pumping problems . . .





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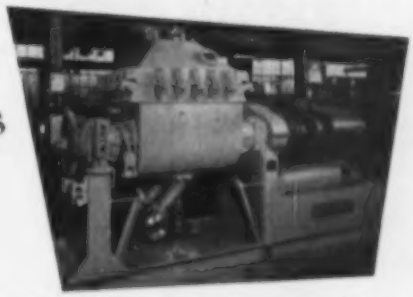

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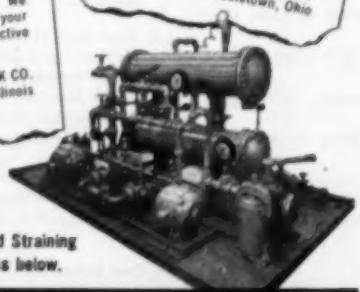

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STUDY COURSES

(*Continued from page* 106)

by the courses offered thus far. Courses of a strictly chemical engineering nature which have been given are Distillation, Heat Transfer, and Thermodynamics. Courses have also been offered in Chemical Economics and Finance, Rapid Reading, Modern Statistical Methods, Technical Writing, and Industrial Psychology. The subject for the most recent course was Cost Estimation.

Quality of Lecturers

The Study Course Committees have consistently had little difficulty in obtaining as lecturers outstanding men in the various fields covered by the courses. All have been very cooperative and eager to work with the committees to make their presentations effective. Some speakers have been obtained from local companies or firms, but many have come from industries and universities outside the immediate area. In all, 44 different lecturers have taken part in the study courses. These have represented ten companies, eleven universities, three consulting firms, one legal firm, one investment brokerage firm, the Federal Reserve Bank at Richmond, Va., and the National Bureau of Standards.

Results

Through January, 1956, nine courses consisting of a total of sixty-three lectures had been presented. The total enrollment in these nine courses was 1190 of which 60 to 70 per cent were members of the local section. The estimated average attendance at each lecture was 105. Although these courses were planned primarily for the younger members of the local section, those enrolled in the courses have represented most fields of engineering as well as other fields, and many levels of engineering experience, from new graduates to those with more than thirty years experience. The continued popularity of the courses and their financial success attest that the courses are considered worth while by the members of the Charleston Section. Also, the fact that on the average 30 to 40 per cent of those enrolled in the courses are not members of the local section indicates that the courses have a broad range of appeal.

It should be emphasized that enrollment in the courses is strictly on a voluntary basis, that no examinations are given, and that no college credit is obtained for completion of the courses. The benefits derived by each individual are therefore largely proportional to the interest he shows and the effort he puts forth. There seems little doubt, however, that the courses have contributed to increased technical competence, to broadening of the field of interest, and to the growth of a sense of professionalism among the engineers participating in the courses. Other local sections would do well to consider the sponsorship of similar study courses for their members.

STUDY COURSES SPONSORED BY THE CHARLESTON SECTION, A.I.Ch.E.

I. Distillation (Fall Semester, 1951)

1. *Introduction and Review of Fundamental Distillation Theory*, E. H. TenEyck, DuPont.
2. *Binary Mixtures*, E. H. TenEyck.
3. *Treatment of Non-Ideal Mixtures*, J. A. Gerster, University of Delaware.
4. *Azeotropic and Extractive Distillation*, E. H. TenEyck.
5. *Multicomponent Distillation—I*, W. C. Edmister, Carnegie Institute.
6. *Multicomponent Distillation—II*, W. C. Edmister.
7. *Bubble-Cap Column Design*, C. E. McConnell, Jr., Carbide and Carbon.
8. *Instrumentation of Still Columns*, John G. Dobson, Foxboro Co.

II. Heat Transfer (Spring Semester, 1952)

1. *General Considerations and Conduction of Heat*, Robert R. Rothfus, Carnegie Institute.
2. *Flow of Fluids, and Simultaneous Heat and Momentum Transfer in Fluids*, Robert R. Rothfus.
3. *Simultaneous Heat and Mass Transfer in Fluids*, Robert R. Rothfus.
4. *Radiant Heat Transmission*, Robert R. Rothfus.
5. *Unsteady State Heat Transfer*, Kenneth O. Beatty, Jr., North Carolina State University.
6. *Liquid Metals as Heat Transfer Media*, Charles F. Bonilla, Columbia University.
7. *Practical Aspects of Heat Exchanger Design*, Daniel A. Donohue, Lummus Co.
8. *Heat Transfer in Agitated Vessels*, J. H. Rushton, Illinois Institute.

III. Chemical Economics and Finance (Fall Semester, 1952).

1, 2. *General Economics*, J. Fred Holly, University of Tennessee.
3. *Money and Banking*, Geo. W. McKinney, Jr., Federal Reserve Bank of Richmond, Virginia.
4. *Financial Organization of Business Enterprise*, A. G. Stone, Rummel, Blagg, and Stone, Charleston, West Virginia.
5. *Investment*, J. Franklin Greenlee, Harris, Upham, and Co., Charleston, West Virginia.
6. *Effect of Government Policies on Business*, T. A. Anderson, Economist with OPS.
7. *Changes in Investment*, Roger Williams, Jr., Roger Williams, Inc., New York.

IV. Rapid Reading (Spring Semester, 1953)

1-6. *Rapid Reading*, Geo. F. Needham, III, Carnegie Institute.

V. Modern Statistical Methods (Fall Semester, 1953)

1. *Introduction, Concepts, Definitions*, W. J. Youden, National Bureau of Standards.
2. *Tests of Hypotheses*, Edwin G. Olds, Carnegie Institute.
3. *Quality Control*, Mason E. Wescott, Rutgers University.
4. *Correlation*, D. J. Kaufman, Washington University.
5. *Analysis of Variance*, Irving W. Burr, Purdue University.
6. *Confounding of Interactions in Preliminary Experimentation*, W. L. Gore, DuPont.
7. *Sequential Designs*, John C. Whitwell, Princeton University.

VI. Thermodynamics (Spring Semester, 1954)

1. *Thermodynamic Principles*, C. M. Sliepcevich, University of Michigan.
2. *Thermodynamic Properties of Fluids*, Joseph J. Martin, University of Michigan.
3. *Expansion and Compression of Fluids*, Robert R. Rothfus, Carnegie Institute.
4. *Low Temperature Heat Transfer*, Joseph J. Martin, University of Michigan.
5. *Thermodynamics of Solutions*, J. A. Gerster, University of Delaware.
6. *Physical Equilibrium*, R. K. Toner, Princeton University.
7. *Chemical Equilibrium*, R. C. Johnson, Washington University.

VII. Technical Writing (Fall Semester, 1954)

1, 2. *Functional English*, W. H. Waldo, Monsanto.
3. *Informal Writing*, Carl F. Prutton, Food Machinery and Chemical.
4, 5. *Formal Writing*, D. O. Myatt, Atlantic Research.
6. *Presentation of Data*, Rod Kilbourne, DuPont.
7. *Writing for Publication*, Sidney G. Kirkpatrick, McGraw-Hill Publishing Co.

VIII. Industrial Psychology (Spring Semester, 1955)

1, 2. *Psychology of People as Employees*, Howard Baumgartel, University of Michigan.
3. *Labor Relations*, E. L. Pleninger, DuPont.
4. *Labor Relations*, E. L. French, Monsanto.
5. *Management Development*, Walter Mahler, Mahler Associates, New York.
6. *Management Development*, W. J. Green, Management Consultant.
7. *Management Development*, James K. Dent, University of Michigan.

IX. Cost Estimation (Fall Semester, 1955)

1. *Introductory Material*, David E. Pierce, Diamond Alkali.
2, 3. *Capital Cost Estimates*, H. Carl Bauman, Chemical Construction Corp.
4. *Manufacturing or Operating Cost Estimates*, Alan E. Lawrence, DuPont.
5. *Criteria of Profitability*, Kenneth H. Kettering, DuPont.
6. *Management Looks at a Cost Estimate*, R. L. Dodge, DuPont.

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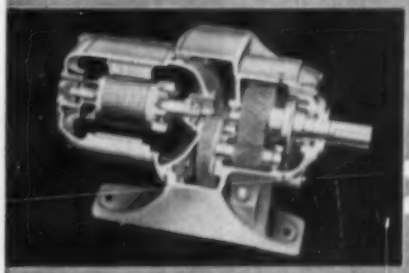

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A.I.Ch.E. **News of the Field** FROM LOCAL SECTIONS

WHITMAN TALKS TO LOCAL SECTIONS

A.I.Ch.E. President Walt Whitman speaks on Atoms for Peace and Decision Making to three local sections.

That scientists from many different countries can work together on a single project and achieve a common goal was illustrated by the Geneva Conference on the Peaceful Uses of Atomic Energy, where representatives of 73 countries planned and held a harmonious meeting. Emphasizing this fact, Walt Whitman, president of A.I.Ch.E. and head of the Chemical Engineering Dept. at MIT, explained that it was the absence of politics that permitted the conference to succeed.

Whitman, speaking to the May meetings of both the **Kansas City** (*L. S. DeAtley*) and **South Texas** (*T. C. Ponder*) **Sections,** pointed out that what disagreements there were at Geneva were mostly between the chemists and the physicists rather than between nations. The conference, Whitman feels, was successful also in that it helped lessen the suspicion and tension among the nations.

Turning specifically to the Soviet Union, Whitman said that while their overall research program may not be as good as ours, it may in many ways greatly excel us in specialized fields.

Decision Making

At the May meeting of the **New York Section** (*A. B. Babcock, Jr.*) Whitman turned his attention to the problems of decision making. Recalling his experiences from numerous high governmental and industrial positions, Whitman emphasized the need for confidence in individuals who prepare recommendations for higher approval. Many high-level policy decisions are merely the approval of lower-level recommendations. Timing is important to all decisions which can be made prematurely as well as too late.

AUTOMATION, DATA PROCESSING AND AWARDS HIGHLIGHT LOCAL SECTION MEETINGS

New York and Boston present awards, South Texas discusses the role and opportunity of the consulting engineer.

"Worth" engineering is the proper approach to the selection of automatic control systems, G. W. McCullough, Phillips Petroleum, told the April meeting of the **Oklahoma Section** (*L. A. Warzel*). The best instruments that can be justified for an installation on a 5-year payout are generally the optimum choice of instrumentation. Consistent product quality and stabilized profits are two important achievements which automatic equipment provides.

One step in automation that can help fill the gap between the estimated 50% increase in production for the next decade and the estimated 14% increase in manpower, is the use of data handling. J. F. Smith, Minneapolis-Honeywell, speaking on the subject of Data Handling in the Chemical Industry to the April meeting of the **Coastal Bend (Tex.) Section** (*W. J. Humphrey*), showed how data is taken through transducers from the analog form instrument output and converted to digital form. By use of several methods of read-out equipment, or by computers, the data is reduced to any final form desired.

Part of 150 students and members at Terre Haute meeting, with panel members standing at right. Panel members, l. to r., McCoy, Dudley, Pitts, Koko, Hite, and Hehner.

The strong interest in data processing and handling was graphically demonstrated at the March meeting of the **Charleston (W. Va.) Section** (*A. W. Byer*) where 229 members and guests gathered to view a demonstration of one particular system—the Taylor Instrument Co.'s Trans-Scan-Log control system. Described by D. Warner of Taylor Instrument, the T-S-L system consists primarily of the electronic equipment necessary to scan each in-

The Harengus Rubrus Award of the Boston Section was presented to W. H. McAdams, MIT, at the April meeting. The award was presented to McAdams (right) by H. Reynolds, "Kingfish" of the section, for McAdams' "inspirational leadership and service to the Chemical Engineering profession."

strument on an instrument panel at the rate of one instrument per second. Main advantages of the T-S-L system, according to Warner, are: (1) Process control systems can be simplified because the logging feature of T-S-L eliminates the need for most individual recorders, also permits simplification and reduction in the size of graphic panels; (2) Control panel space requirement is reduced to less than 50% of that for a conventional instrument setup; (3) Logging and alarm features free operating personnel from routine duties, permit more effective process supervision; (4) There is a complete data recording system; (5) The system is easily adaptable to changing process conditions.

At the March meeting of the **East Tennessee Section** (*R. F. Hunt, Jr.*) the computer aspect of data processing came up, with C. Benton, Jr., IBM, showing that in the last five years computers have increased in speed 10,000 times with only a four or five-fold increase in cost. At present, not too much is being done with computers in engineering work or automatic process control, but active growth is expected in these areas.

Professional Development

The importance of instilling in the young engineer the desire to develop professionally cannot be over-emphasized. With this main point, H. M. Miller, DuPont Engineering Department, discussed "Professional Development—A Problem for the Engineer" at the March meeting of the **Savannah River Section** (*C. L. Howard*). During his talk, Miller pointed to the recent "Statement on Professional Standards" published by A.I.Ch.E. in C.E.P. as the best statement on this subject which has been published to date.

A broader treatment of the same

(*Continued on page* 112)

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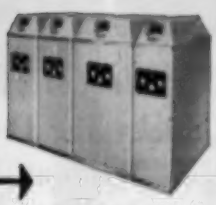

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A.I.Ch.E. News of the Field
FROM LOCAL SECTIONS

(*Continued from page* 111)

subject formed the program at the **Terre Haute Section's** (*T. W. Cundiff*) symposium at its annual Student Affairs Day meeting. "The Chemical Engineer in Society" was the subject, W. E. McCoy, Pfizer, moderated. Speakers were: J. F. Dudley, Commercial Solvents, on "The Engineer in Civic Affairs"; W. Keko, Commercial Solvents, on "Non-Engineering Aspects of the Job"; G. L. Pitts, Pfizer, on "The Engineer and His Church"; H. Hehner, Monsanto, "The Engineering Student in Extra Curricular Activities from Industry's Viewpoint"; and "The Engineering Student in Extra Curricular Activities from the College Viewpoint," by S. Hite, Purdue.

Stephen L. Tyler presents the first Stephen L. Tyler Award to R. E. Treybal (left) of New York University for his book, *Mass Transfer Operations*. The award, made annually for the best published article or book written by a New York Section member, consists of an award certificate and an engraved desk set. A special duplicate award went to John Happel (see About Our Authors, p. 49, this issue).

Power and the Atom

D. K. Davies, Babcock & Wilcox, expert on stress analysis and nuclear equipment, discussed power from atomic energy at the May meeting of the **Akron Section** (*T. H. Rogers*). Describing in detail the engineering principles, and the advantages and disadvantages, of the six promising types of industrial power reactors, Davies indicated that at the present time the higher cost of building atomic power plants made power from fossil sources cheaper in the United States, although not necessarily in other countries. By the year 2000, according to Davies, some 16.7% of all power produced in this country will be atomic. On the other hand, by 1960 Great Britain will have 5 atomic power plants in operation.

Looking at it from the other side, G. G. Brown, Univ. of Michigan, speak-

ing on energy supplies for the future to the March meeting of the **Rochester Section** (*J. E. Millard*), pointed out that power consumption increases at a rate of 3½ to 4% per year, world's supply of fossil fuels will last 60 years at U. S. per capita consumption rate. By 1975, in Brown's view, 60% of all new construction will be for nuclear power. Solar energy should not be overlooked, either.

At the same March meeting in Rochester, the **Student Chapter of the Univ. of Rochester** was also present, and a national A.I.Ch.E. award went to the student with the highest marks for the first two years of a chemical engineering course. The winner—Miss Elizabeth A. Carruthers! C.E.P. congratulates the young lady chemical engineer.

The Consulting Engineer

The main purpose of a consultant is to represent the best interest of his client. A. E. Dukler, partner in the firm of Prengle, Dukler and Crump, consulting engineers, stressed this fact to the March meeting of the **South Texas Section** (*G. B. Gibbs*).

A consultant's only commodity is service and information. A chemical engineer contemplating entry into consulting work must first decide whether or not his background is broad enough to offer his services in a general way, or whether he would do better to specialize in one branch of the profession.

Some of the reasons a client may need a consultant are: (1) no engineering staff; (2) work outside the scope of the present engineering staff; (3) a different viewpoint is needed; (4) an overloaded staff; or (5) the work requires the training of a specialist.

Also Meeting

Southern California Section (*F. G. Sawyer*) in February heard the chemical engineering problems involved in large liquid propellant rocket power plants from J. Torme, Rocketdyne, a subsidiary of North American Aviation . . . **Midland Section** (*J. Eichhorn*) in March met with P. W. Gillis, Univ. of Kansas, on High Temperature Chemistry, heard of the lack of accurate physical data in this field . . . **St. Louis and Alton-Wood River Sections** (*K. R. Hancock*) held a joint meeting in March and received a prediction of what the automobile of the future would be like: light weight materials will be one key . . . **Rhode Island Section** (*A. R. Thompson*) held annual Ladies Night in March, heard H. B. Sturtevant, Rhode Island School of Design, acquaint the ladies and engineers with "The New Textile Fibers."

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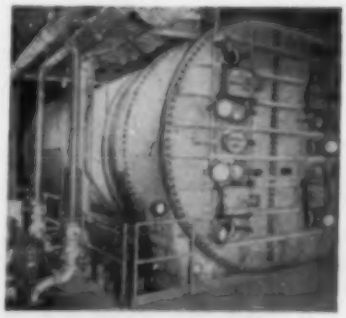

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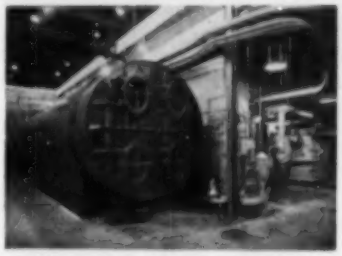

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people

H. B. McClure is elected a vice president of Union Carbide and Carbon Corp., and **D. B. Benedict** (left) is appointed president of Carbide and Carbon Chemicals Co., a division of Union Carbide, N. Y. Mr. McClure joined Union Carbide in 1928, and subsequently became manager of the fine chemicals division of Carbide and Carbon Chemicals Co. in 1936, vice president in 1944, and president in 1954.

Mr. Benedict began his employment with Union Carbide in 1933, becoming assistant superintendent in 1940, and assistant works manager in N. Y. in 1953. A year later he was appointed works manager for the company, and in 1955 became a vice-president of Carbide and Carbon Chemicals Co.

Rudolf Cziner has joined the newly-created product research and development division of United Merchants and Manufacturers, Inc., N. Y. C.

Murray C. Udy is made director of research with the newly-organized Strategic-Udy Processes, Inc., Niagara Falls, N. Y. Dr. Udy was for 17 years with Battelle Memorial Institute, most recently as assistant chief, ferrous metallurgy division.

Albert J. Gracia, manager of research and development for Goodyear Tire and Rubber Co., is shown above as he received the P. W. and Florence B. Litchfield Special Award of Merit for his role in organizing Goodyear Atomic Corporation, operator of the Pike County atomic energy installation.

Bruce L. Calder joins the general engineering department of the Flintkote Co. as chemical engineer. He had previously been affiliated with the Toms River-Cincinnati Chemicals Corp.

W. E. Bratton and **R. L. Clarke** have been added to the staff of The M. W. Kellogg Co. to administer and handle engineering and construction contracts in the petroleum and petrochemical fields.

Jack Tielrooy and **Robert S. Ray** are appointed vice presidents of Brea Chemicals, Inc., Los Angeles, a subsidiary of Union Oil Company of California, to be in charge of development and manufacturing, respectively.

Max E. Bretschger, president of the Becco Chemical Division of Food Machinery and Chemical, has retired after thirty years with the company. **Frederick A. Gilbert** will succeed Dr. Bretschger.

W. Roberts Wood elected president of the Girdler Co., Louisville, Ky., a division of the National Cylinder Gas Co. He joined Girdler in 1929 and 10 years later was made manager of the gas processes division. He was elected vice president in 1941 and executive vice president in 1948. In 1953 he became a vice president and director of the National Cylinder Gas Co.

Walter Dong joins Shell Development, Emeryville, Cal., as an engineer in the experimental plants department.

Kenneth S. Watson, consultant for the General Electric Co. on water management and waste control, appointed by the Secretary of State as engineer advisor to the U. S. Delegation to the Ninth Meeting of the World Health Assembly in Geneva, Switzerland.

Arthur S. Weygandt becomes manager of Food Machinery and Chemical Corp.'s chemicals central development department, with headquarters in N. Y. Mr. Weygandt was formerly with du Pont as technical director and a director of Duperial Argentina, a joint operation of du Pont and Imperial Chemical Industries, and also spent several years with the technical division of the du Pont foreign relations department.

VAN ANTWERPEN HONORED FOR DECADE OF SERVICE

Above, general view of the luncheon scene, and below, Mr. & Mrs. Van Antwerpen.

F. J. Van Antwerpen, secretary and publisher of A.I.Ch.E., was recently honored at a luncheon given in his behalf by the staff of the Institute at the Chemists' Club in New York. Mrs. Van Antwerpen and Stephen L. Tyler, retired secretary, were among the guests.

Key to the hour-long program of entertainment was humor, befitting both the tastes and the personality of the honored guest. A series of presentations were made, either of handicrafts or prose (and occasional poetry), all depicting or citing some particularly outstanding moment in the steady stream of what now appear to be highly humorous events which have taken place since Van's arrival on the Institute scene.

In his own remarks, Van recalled that in 1946 the office occupied but one corner of Dr. Berolzheimer's laboratory in one of the darker and less well ventilated sections of the Chemists' Club of that day. Membership then—6043.

On the serious side, Van's arrival marked the beginning of the era of growth and expansion of services rendered by the Institute. A tribute to the importance of Van Antwerpen's contributions was expressed by Mr. Tyler.

Perhaps most symbolic of the expressions of good fellowship read during the "serious" part of the ceremony was the text of a certificate written by staff members and printed in special form by the Ferguson Co., printers of C.E.P.

KNOW' all men by these presents that: in recognition of his ten years of selfless servitude; for bearing, with patience and fortitude, the slings and arrows of outraged authors, members and other critics; for his smiling courage in the face of the manifold vicissitudes of time, of life, and the fortunes of publishing; for responding faithfully and promptly to the calls and alarums of stern duty; this scroll is presented to—

FRANKLIN JOHN VAN ANTWERPEN

as a token of the affectionate esteem in which he is held by his co-workers, the staff of the American Institute of Chemical Engineers.

John B. Sutherland is named product research manager by Butler Manufacturing Co.

Leland W. Blazey is made assistant director of engineering in the chemical division of Merck & Co.

Irving Roberts is appointed director of planning by Reynolds Metals Company and will have his headquarters in Richmond, Va.

John LaBash, Jr., formerly with Stewart Warner Corp., has joined Eli Lilly and Co. as a project engineer.

Charles E. Wilson has retired as chairman of the board of directors of W. R. Grace & Co. The former chairman of the Defense Mobilization Board plans to devote himself to public service tasks. Also at Grace, in the polymer chemicals division, **Anthony J. Bruno, Jr.**, is appointed technical manager of the multi-million-dollar Grex polyolefin resin plant now being built at Baton Rouge.

J. Edwin Bride has left Battelle Institute to join Diamond Alkali Co.

(*Continued on page* 122)

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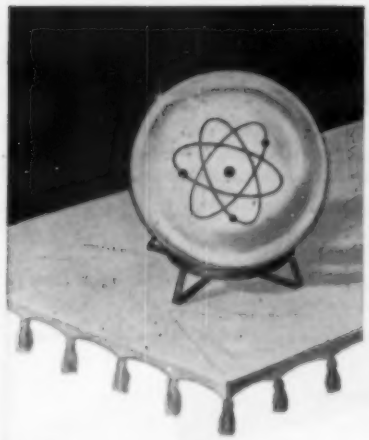

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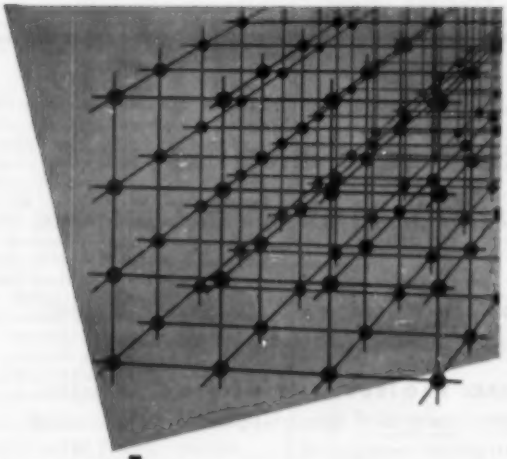

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2. Degree in ChE or physical chemistry with up to 5 years experience. To carry out research and process development for the extrusion of synthetic fibres and to develop processes for producing new fibres and for improving existing ones.

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ENGINEERING SALES SPECIALIST—Experienced sales specialist to assume senior post as customer contact man in rapidly growing Project Engineering Section of leading chemical equipment manufacturer. Ability required to expand customer equipment inquiries into complete engineered plants and to negotiate contracts therefore. Engineering degree and considerable heavy experience necessary. Salary and bonus in five figures in accordance with background. Liberal benefits. Send complete résumé and salary requirements. Box 4-6.

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Send résumé and salary requirements to:

Personnel Department
Westvaco Mineral Products Division
Food Machinery and Chemical Corporation
P. O. Box 337
Newark, California

POSITION OPEN—For a recent graduate in chemical or metallurgical engineering in chemical engineering division of Midwest atomic energy laboratory for research and development of reactor fuel recovery process. Publications are encouraged. Salary commensurate with training and experience. Box 23-6.

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A.I.Ch.E. Members

M.Ch.E.—Age 33. With twelve years' management and operating experience in production, engineering design and construction, production control and planning, cost estimating and control, and traffic in organic chemicals and pharmaceuticals, desires management position with a chemical company. Box 6-6.

CHEMICAL ENGINEER—Age 38. Development and process engineer. Seventeen years' diversified experience organic chemicals manufacture, technical and supervision. Aggressive, good personality, mature judgment. Desire permanent management or technical position with advancement potential. Box 7-6.

CHEMICAL ENGINEER—Mature judgment of fifteen years' supervisory experience petroleum refining, detergents, cracking catalysts, acid production, research, Navy electronics and sales. B.S. 1941. Box 8-6.

CHEMICAL ENGINEER—B.Ch.E. 1949. Age 34, married, veteran. Five years' experience plant operation synthetic organics and insecticides. Some supervision. Desire work in process or product development or operation. Prefer Southeast. Box 9-6.

YOUNG EXECUTIVE ENGINEER—Age 34, B.S.Ch.E. Seeking challenging position with top notch company large or small. Broad administrative and supervisory experiences. Competent to direct a manufacturing plant. Box 10-6.

VERSATILE EXECUTIVE-ENGINEER—Ph.D. in Ch.E. Age 37. Presently head, university chemical engineering department. Broad experience in research and development, thermodynamics, economic design, management, seeks to reenter industry. Capable of the utmost responsibility. Box 11-6.

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people

(*Continued from page* 115)

Edward J. Massaglia is made general manager for operations in Atlas Powder's chemicals division, replacing **W. Clayton Lytle** who becomes assistant to vice-president **D. J. Carrol Copps** of the explosives department. In the economic evaluation department, **Alan G. Bates** is made a project engineer and **Frank L. MacArtor** a senior project engineer.

Werner C. Muller is named manager of the project development section of U. S. Industrial Chemical's development department.

F. M. Warzel recently appointed process engineering section head at the Chemical Processing Plant of Phillips Petroleum, Idaho Falls, Idaho.

the chemical engineer in MARKETING

Edwin H. Wolfe joins the Antara chemicals division of General Aniline & Film Corporation as assistant manager of the textile, leather, and paper chemicals department, where he will work toward developing chemical sales in the paper and leather trades.

Norman P. Phillips is appointed technical sales representative for General Tire & Rubber Company's Gen-Flo paint latex. He will assist General's sales agents with technical and merchandising information.

Edmund A. J. Mroz, of Melrose, Mass., is made Northeast sales and service engineer for the Carboline Co., St. Louis, manufacturers of corrosion-resistant maintenance coatings, tank linings and floor coverings. Mroz was formerly with the Badger Process Division of Stone & Webster.

The Permutit Company, New York, announces the appointment of **J. A. Meindl** as sales representative in the Toronto office of its Canadian branch. **J. M. Watson** will succeed Meindl as sales representative in the Montreal office.

Joseph M. Young, formerly Southwest area field sales engineer for Infilco, Inc., is transferred to the Tucson headquarters of the ion-exchange department. **Lee Hiser,** of the Tucson engineering department, will replace Young in the Southwest.

SITUATIONS WANTED

(*Continued*)

CHEMICAL ENGINEER—M.S., P.E. Fourteen years' development evaluations, plant improvement, complete plant design, technical supervision, and construction liaison for industrial organics seeks challenge as engineering director, department head, or plant management. $13,500. Box 12-6.

TECHNICAL SALES—B.S. in Ch.E. 1952. Experience in pilot plant and technical services for petrochemical plant. Company administrated aptitude tests indicate strong sales potential. Prefer South. Present salary $6500. Age 27, veteran, family. Box 13-6.

PROCESS DESIGN ENGINEER—B.Ch.E. 1952. Age 29, married, veteran. Four years' diversified design experience with major contractor. Desires responsible position with future in New York-New Jersey area. Desired salary $7500. Box 14-6.

CHEMICAL ENGINEER—M.S. 1955, 1½ years' nuclear engineering; heat transfer, stress analysis, equipment design. Three years' field experience petroleum plant construction; creative and resourceful in novel engineering problems. Desire non-security classified employment. Inquiry from small organization especially invited. Box 15-6.

CHEMICAL ENGINEERING—Excellent engineering foundation. Five years' varied experience pilot plant, development, research. Desire professional work, challenging responsibilities, advancement with small midwestern company. Present salary $8500. Age 32, family, veteran, Ph.D. Box 16-6.

DIRECTOR RESEARCH & DEVELOPMENT—major company. Due to policy changes seeking comparable position elsewhere. Age 46, chemist-chemical engineer. Twenty years' diversified experience, research, engineering, administration. Salary $16,000. Box 17-6.

CHEMICAL ENGINEER—B.Ch.E., "with distinction" 1951. Age 26. Petroleum process improvement and loss reduction. Naval electronics experience. Graduate work in business administration and statistics. Need responsible and demanding position to be satisfied. East Coast. Box 18-6.

SUMMER POSITION—M.Ch.E. Graduate student, expecting Ph.D. in June, 1957. Desires work for research and development in the Northeastern area. Box 19-6.

CHEMICAL ENGINEER—Desires position at junior management or supervisory level. Ten years' intensive research, development, manufacturing and administration, bench to plant scale operations. Diversified background—lacquers, propellants, explosives, related chemicals. Capable of assuming responsibility. Good record of accomplishment. B.Ch.E., age 31, any location. Box 21-6.

CHEMICAL ENGINEER—Ph.D. Twenty years' diversified experience. Petroleum, petrochemicals, organics. Desires responsible position in Midwest. Box 24-6.

CHEMICAL ENGINEER—Twenty years' experience all phases oil and fat industry, domestic and foreign. Available. Résumé on request. Box 22-6.

Miscellaneous

FOR SALE—Chemical Engineering Progress, 1947-1953, seven bound volumes, $70. Box 20-6.

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Paul C. Hutchinson is appointed director of sales for the instrument division of the Perkin-Elmer Corp. He will be responsible for sale of laboratory analytical instruments as well as infrared analyzers for continuous stream control in chemical processing plants.

J. William McCrackin joins Mobay Chemical Company as technical service representative and will work with the customer service group in Mobay's research and demonstration laboratories. Holder of a chemical engineering degree from Washington University, McCrackin was formerly a general manufacturing superintendent at Monsanto's Queeny plant.

D. W. Thornburg is named plastics sales engineer in the New York district office of Phillips Chemical Company's plastic sales division to be established this summer.

Kenneth C. Frazier is appointed manager, general products sales department, Olin Mathieson Chemical Corp., handling general product sales planning and programming. Field sales activities will be under **Derek Richardson,** manager, and **O. J. Theobald, Jr.,** assistant manager. Managing a newly-established sales development department will be **Laurence E. Russell,** handling technical service, market development, and market research.

Necrology

Stuart Duncan, 72, board chairman of Marquette Cement Manufacturing Co.

Norman J. Burd, 46, vice president and director of manufacturing, Norwich Pharmacal Co.

H. S. Kendall, 62, assistant to the president, Dow Chemical Co.

Frederick H. Leonhardt, 83, board chairman of Fritzsche Brothers and its affiliate, Dodge & Olcott, Inc.

Carl Pletscher, 76, retired first vice-president of Baker Perkins, Inc.

E. A. Hauser, 59, Dept. of Chemical Engineering, M.I.T.

Nathaniel McL. Sage, 66, director of the Office of Sponsored Research, M.I.T.

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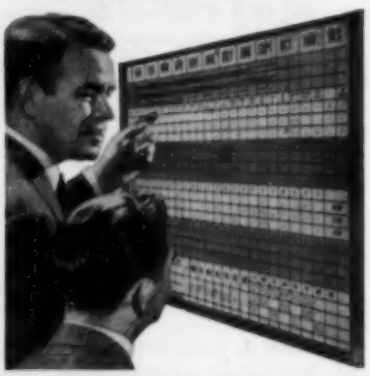

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news and notes of A.I.Ch.E.

Accomplishments at New Orleans: New Orleans, in my opinion, witnessed more solid achievements for our Institute progress & well-being than have been recorded in a long time . . . New Orleans also saw the beginning of committee meetings held during National meetings . . . Program & Membership groups talked about their problems & of course the Sections Activities Committee meeting with Local Section officers provoked much discussion & aired feelings & attitudes which will be reflected in future actions of Council . . . The Council agenda were lengthy, the members sitting for well over eight hours on Sunday, and even then much of the policy material up for discussion had to be tabled . . . Council at its luncheon honored H. C. Parmelee . . . Parm, as he is known to many members, was the Institute's second secretary, from 1927 to 1929 . . . He is now retired & lives in Bradenton, Florida . . . At the luncheon he was presented with the Secretary's pin, similar to the one given to S. L. Tyler on his retirement over a year ago. **Council Minutes:** Much discussion on divisions . . . As members know, we have a Nuclear Engineering Division . . . M. C. Leverett, present chairman, reported on its activities and accomplishments & then all members of Council discussed the place divisions have in the A.I.Ch.E., with the result that an *ad hoc* committee was appointed consisting of G. E. Holbrook, chairman; L. J. Coulthurst; D. L. Katz; and W. R. Marshall, Jr., to recommend by November 2 a suitable course of action on additional divisions . . . Up for consideration by Council are a Heat Transfer & an Engineering Economics Division . . . Fiftieth Anniversary Meeting in June, 1958, is to be designated an international meeting & President Whitman was empowered to take the necessary steps with the State Department . . . J. H. Rushton, chairman of the Sections Activities Committee, presented a report . . . Among other things a certificate has been prepared by the Executive Secretary's office for Local Section use in recognizing the actions & efforts of retiring chairmen of the sections . . . The certificate is now ready & if any Local Sections wish to present copies to chairmen either at the final June meeting or at the first meeting in September, will they please get their requests in early . . . Further, a suitable emblem in the form of a lapel button is to be made available for sale to Local Sections for presentation to retiring chairmen & the design is now underway in the Secretary's office . . . Barney Dodge reported on the new engineering center . . . Incidentally, the July issue of C.E.P. will contain two very important reports from our former President, one on the location of the new engineering center & the second on the Nominating Committee list of candidates for Institute offices . . . Any nominations by petition received up to publication will also be included . . . A detailed report by D. F. Othmer, Chairman of the Study Committee on Student Affiliation, was also made to Council . . . As a result of one of his recommendations, the $5 entrance fee for Associate Membership may be waived for all Student Members who apply before December 31 of the year they leave school . . . Council also authorized the establishment of the Great Salt Lake Section, took action on accreditation, and voted to cosponsor Subcommittee VI of the American Standards Association . . . This committee will study standardization in the field of nuclear energy & Ray Genereaux, former Chairman of the Nuclear Engineering Division, is slated to be its chairman. **New Committee Personnel:** Agitators Subcommittee of the Equipment Testing and Procedures Committee, John Connolly . . . new chairman of the Professional Legislation Committee, J. P. Cooke . . . P. J. Wilson, Jr., member-at-large of the Public Relations Committee . . . Thomas H. Vaughn, American Standards Association Committee K63 to develop standards for cleaning-and-maintenance supplies . . . Ralph E. Peck, U. S. National Committee on Theoretical and Applied Mechanics . . . Charles E. Dryden, Vocational Guidance Committee . . . Former president Frank J. Curtis will represent the A.I.Ch.E. this July in London at the 75 Anniversary of the Society of Chemical Industry. **Personal Note:** Council presented another Secretary's pin at New Orleans, this one to me . . . It was a fine gesture, one I deeply appreciate, & the occasion was the celebration of my tenth anniversary with the A.I.Ch.E., I having begun in April, 1946, with the idea of starting *Chemical Engineering Progress* . . . The staff of the Institute gave me a surprise party at The Chemists' Club & presented me with many mementos & gifts I shall cherish . . . The staff also donated in my name a sum of money to the Albert Schweitzer Foundation . . . These actions by Council & by the staff are all deeply appreciated by me. The work I have done at the Institute & C.E.P. has been exciting and challenging & I look forward to the future of chemical engineering & the Institute with a great deal of optimism & enthusiasm. F.J.V.A.

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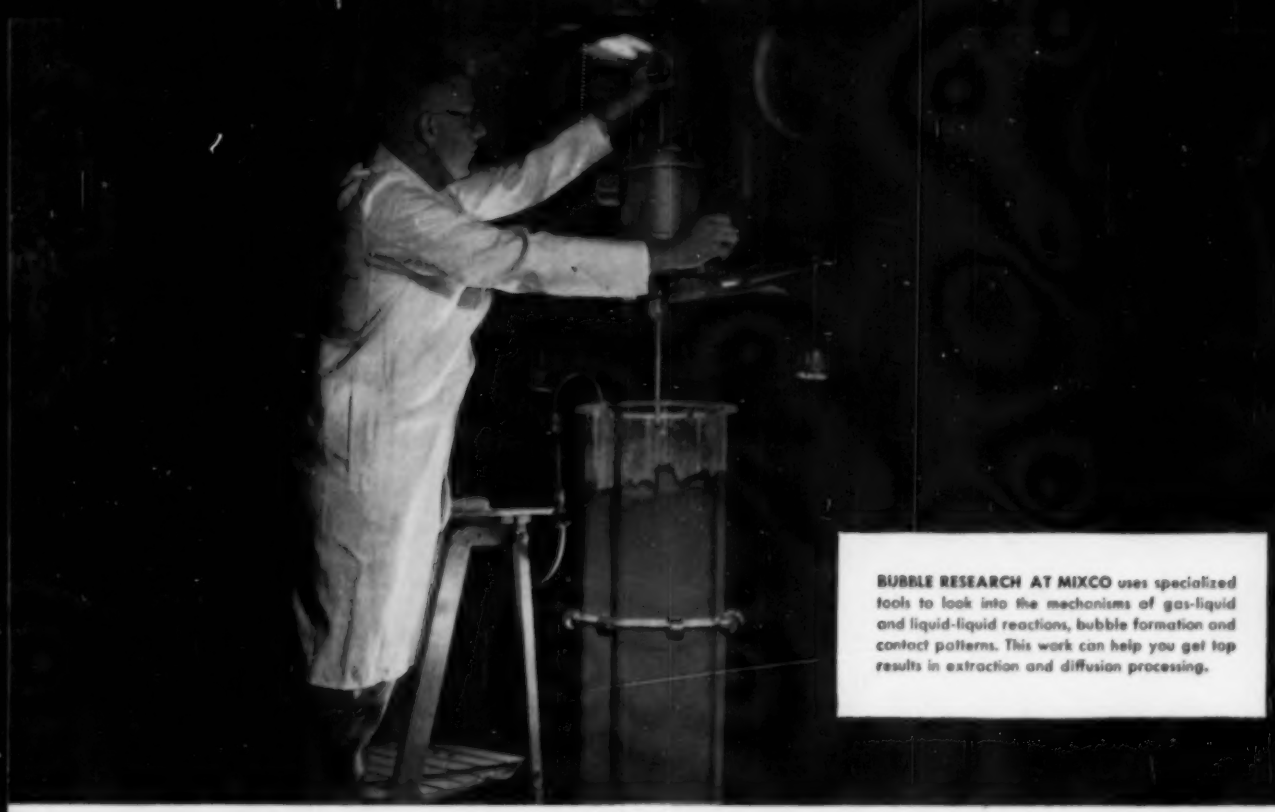

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